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BEFORE THE ARIZONA CORPORATION COMMISSION

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AZ CORP COMMISSION
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Arizona Corporation Commission
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JAN 20 2011

DOCKETED BY

COMMISSIONERS
GARY PIERCE, Chairman
BOB STUMP
SANDRA D. KENNEDY
PAUL NEWMAN
BRENDA BURNS

IN THE MATTER OF THE COMMISSION'S GENERIC EVALUATION OF THE REGULATORY IMPACT FROM THE USE OF NON-TRADITIONAL FINANCING ARRANGEMENTS BY WATER UTILITIES AND THEIR AFFILIATES

Docket No. W-00000C-06-0149

The Global Utilities,[1] file the attached workshop presentations that were presented at the workshop on January 14, 2011, by Paul Walker, Graham Symmonds and Timothy J. Sabo, together with the source documents referenced in the presentations, as shown in the list of documents below:

1. "Distribution System Improvement Charges", presented by Paul Walker;
2. "DSICs, Water Loss and Human Health", presented by Graham S. Symmonds;
3. "DISC Legal Overview", presented by Timothy J. Sabo;
4. National Risk Management Research Laboratory, "Aging Water Infrastructure Research Program: Addressing the Challenge Through INNOVATION", March 14, 2007;
5. American Water Works Association, "Dawn of the Replacement Era: Reinvesting in Drinking Water Infrastructure", May 2001;
6. The National Regulatory Research Institute, "The Water Industry at a Glance", April 2008;
7. The National Regulatory Research Institute, "Financing Mechanisms For Capital Improvements For Regulated Water Utilities", December 1999;
8. GAO, "Water Infrastructure, Information on Financing, Capital Planning, and Privatization", August 2002;

[1] Hassayampa Utility Company, Inc., CP Water Company, Global Water – Picacho Cove Utilities Company, Global Water Picacho Cove Water Company, Global Water – Palo Verde Utilities Company, Global Water – Santa Cruz Water Company, Valencia Water Company – Town Division, Valencia Water Company – Greater Buckeye Division, Water Utility of Greater Tonopah, Inc. and Willow Valley Water Co., Inc.

9. Congressional Research Service, "Report for Congress: Water Infrastucture Needs and Investment: Review and Analysis of Key Issues", Updated November 24, 2008;

10. Walter Lynch, American Water, "The Benefits of Infrastructure Replacement Surcharges", NARUC 120th Annual Convention, November 17, 2008;

11. LeChevallier, Gullick & Karim, "The Potential for Health Risks from Intrusion of Contaminants into the Distribution System from Pressure Transients", American Water Works Service Company, Inc.;

12. Craun et al, "Waterborne outbreaks reported in the United States", Journal of Water and Health 2006;

13. Nygard et al, "Breaks and maintenance work in the water distribution systems and gastrointestinal illness: a cohort study", International Journal of Epidemiology 2007; and

14. Hunter et al, "Self-Reported Diarrhea in a Control Group: A Strong Association with Reporting of Low-Pressure Events in Tap Water", Clinical Infectious Diseases 2005.

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RESPECTFULLY SUBMITTED this 20th day of January, 2011.

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Distribution System Improvement Charges

Presented to the Arizona Corporation Commission, Water Workshop #2

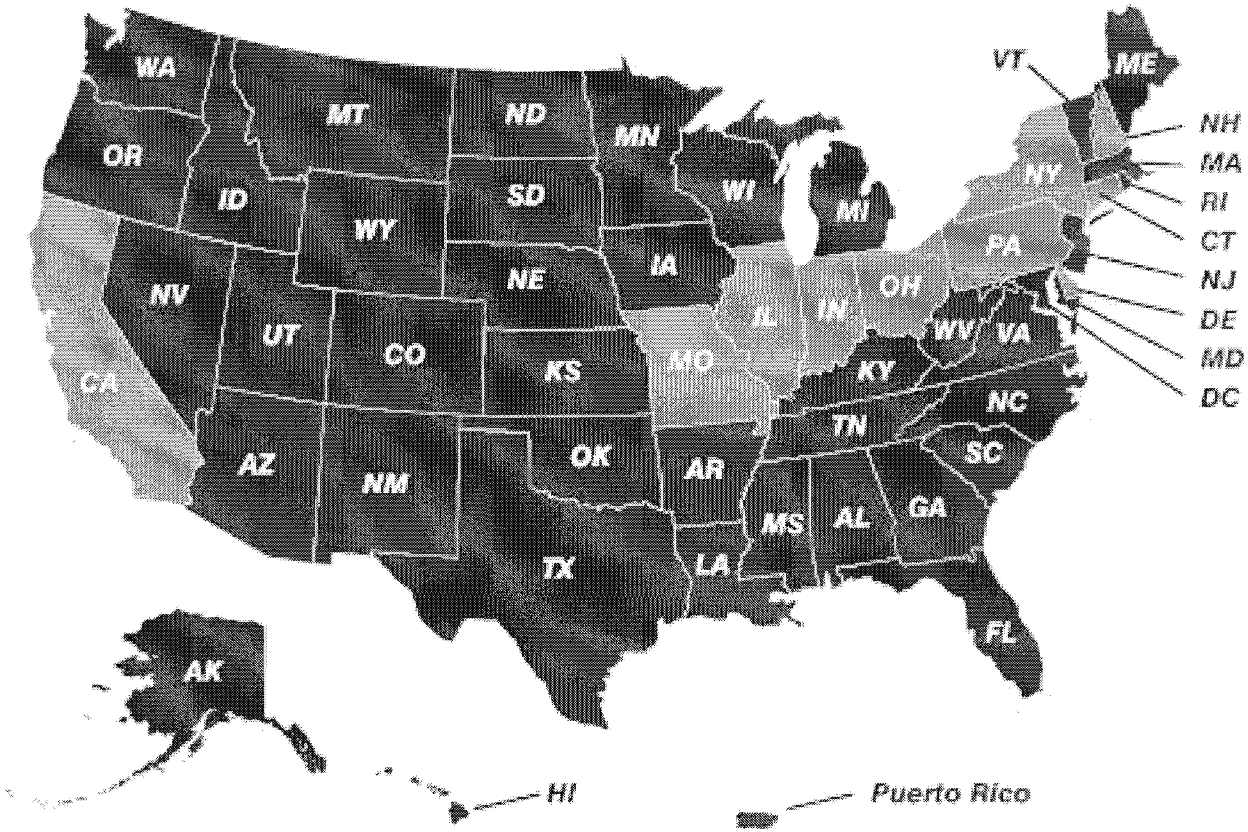
What are DSICs?

- Adjustor mechanisms that pass through the capital costs (WACC + depreciation) of designated water and wastewater replacement infrastructure without the need for a full rate case.

DSIC Features

- Capped surcharge - % of revenues, 5-10% is the range across PUCs,
- DSIC filings made periodically, surcharge changes approved (review is ‘on paper’ not through hearings),
- DSIC filings usually quarterly,
- DSIC audits and Rate Cases provide increased regulatory oversight.

States with DSICs



Source: National Association of Water Companies www.nawc.org

January 14, 2011 Insight Consulting, LLC DOCKET NO. W-00000C-06-0149

What charges go into DSICs?

- DSICs generally include:
  - Replacement of: services, meters, main, valve, and hydrants,
  - Main extensions that ameliorate health/supply issues, e.g., looping distribution systems,
  - Main cleaning and relining,
  - Facility relocation due to highway/road construction.

Major Financial Challenges facing U.S. Water and Wastewater

Increasing environmental standards

\+

Population Growth

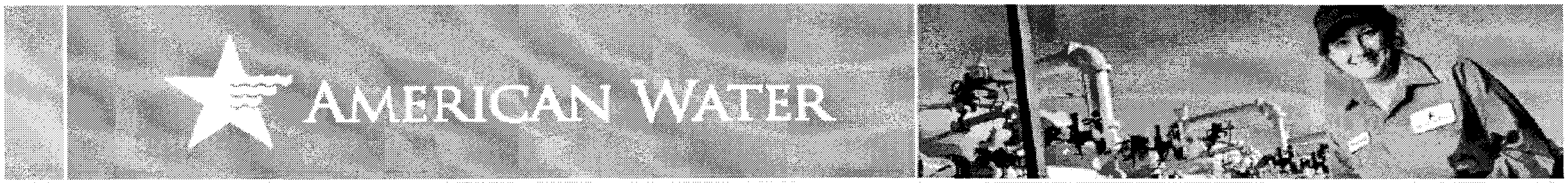
\+

Aging Infrastructure

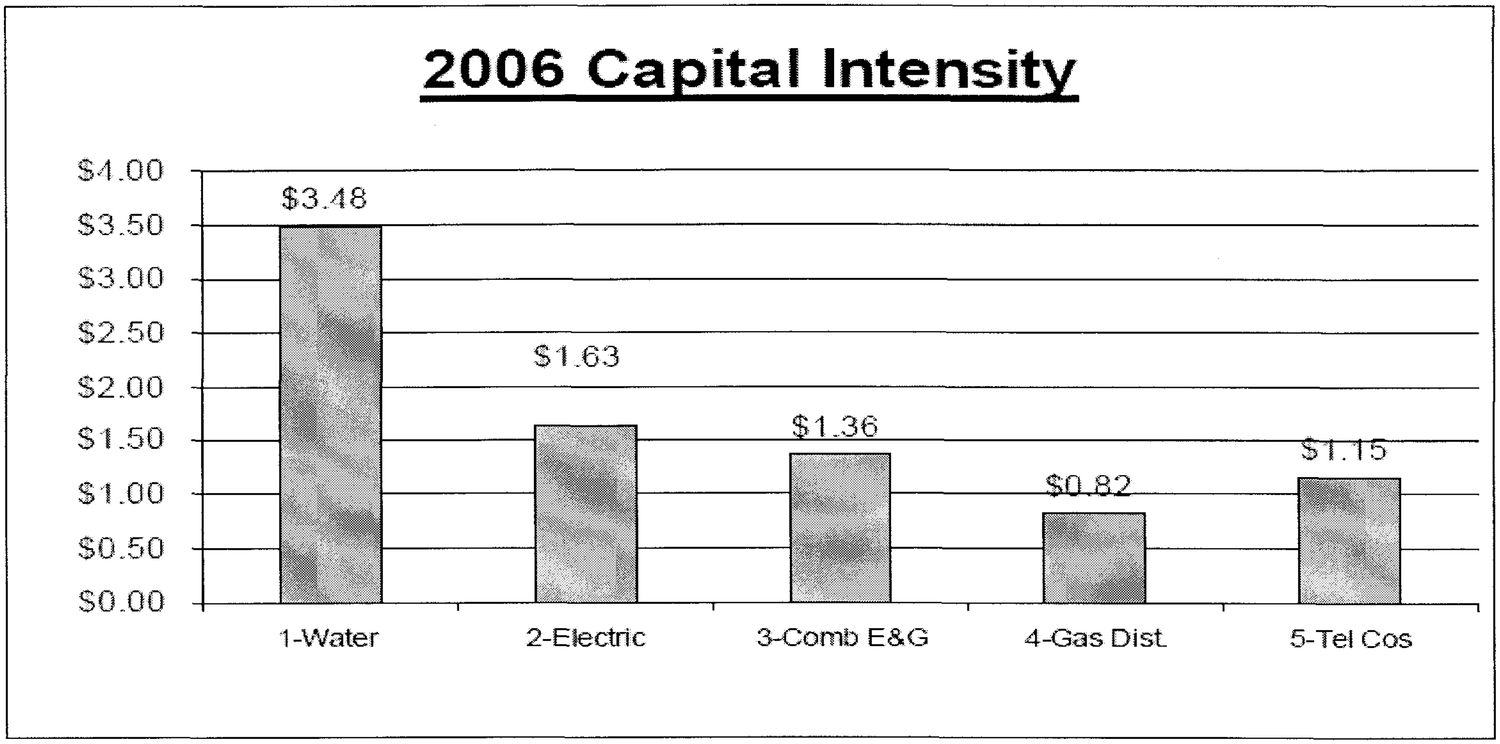
=

Large Infrastructure Needs

Why we need DSICs



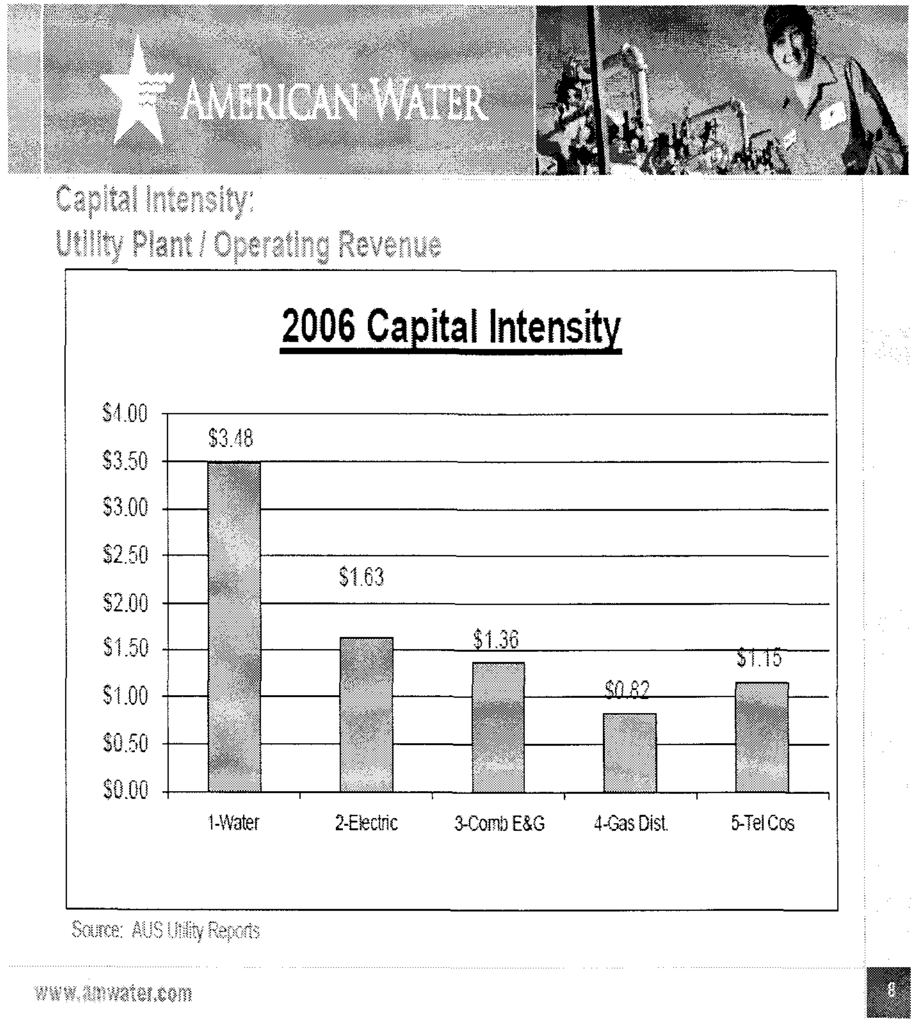
Capital Intensity:
Utility Plant / Operating Revenue



Source: AUS Utility Reports

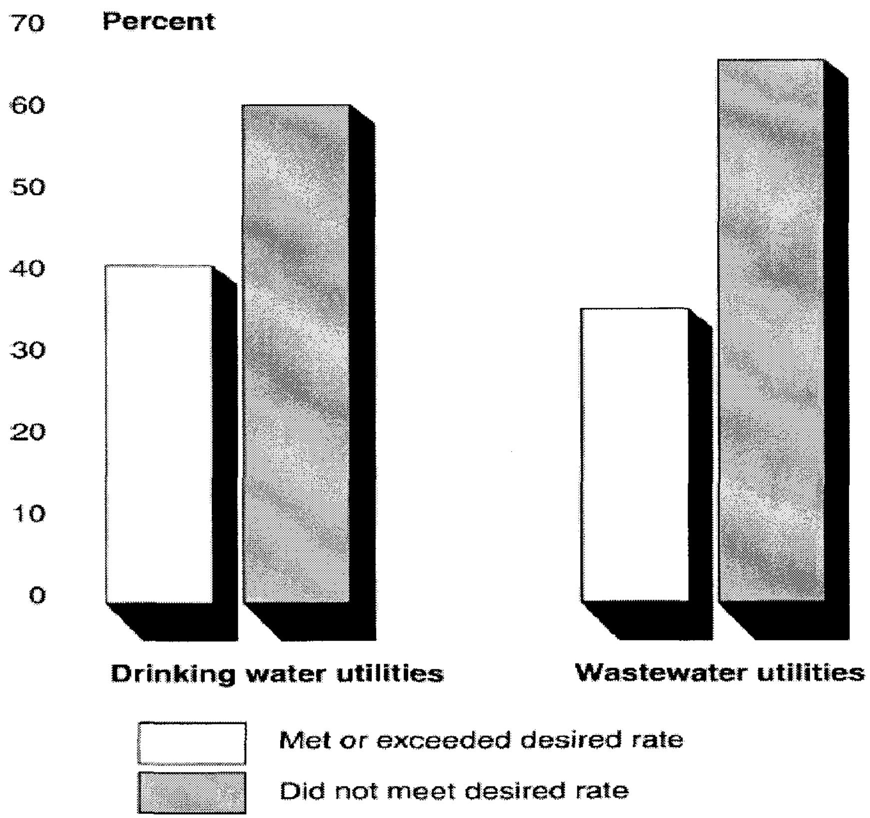
Why we need DSICs

This graph shows the plant/revenue ratios for utilities – gas and electric aren't "easier money" - they have much higher variable costs. That's why they have adjustor mechanisms for variable costs.



Why we need DSICs

Figure 2: Extent to Which Utilities' Actual Rate of Pipeline Rehabilitation and Replacement Met or Exceeded Their Desired Rate (on average, fiscal years 1998 through 2000)



Source: GAO's analysis of survey data.

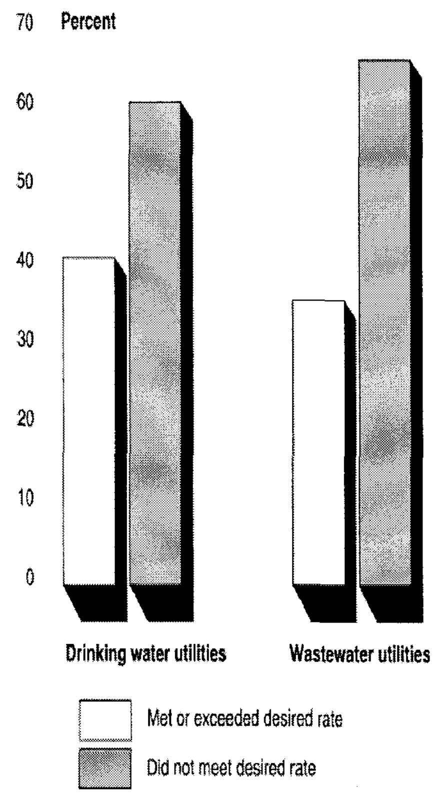
GAO
Accountability * Integrity * Reliability

US GAO Report 02-764, "Water Infrastructure" Aug. 2002, Page 42

Why we need DSICs

This graph shows that the replacement rate implied by depreciation schedules is not being met: Plant is either lasting longer than it was expected to, or we are failing to invest in our future needs.

Figure 2: Extent to Which Utilities' Actual Rate of Pipeline Rehabilitation and Replacement Met or Exceeded Their Desired Rate (on average, fiscal years 1998 through 2000)



Source: GAO's analysis of survey data.

Infrastructure Investment Needs 20 Years (EPA Model)

Water

$276 Billion

Wastewater

$202 Billion

TOTAL: $478 Billion

U.S. Congressional Research Service, "Water Infrastructure Needs and Investment: Review and Analysis of Key Issues", November 24, 2008 Page CRS-13

20 Year Infrastructure Investment Needs

(CBO Model, low & high cost scenarios)

Water:

$232 to $402 Billion

CONGRESSIONAL BUDGET OFFICE

Wastewater:

$260 to $418 Billion

TOTAL: $492 to $820 Billion

U.S. Congressional Research Service, "Water Infrastructure Needs and Investment: Review and Analysis of Key Issues", November 24, 2008 Page CRS-13

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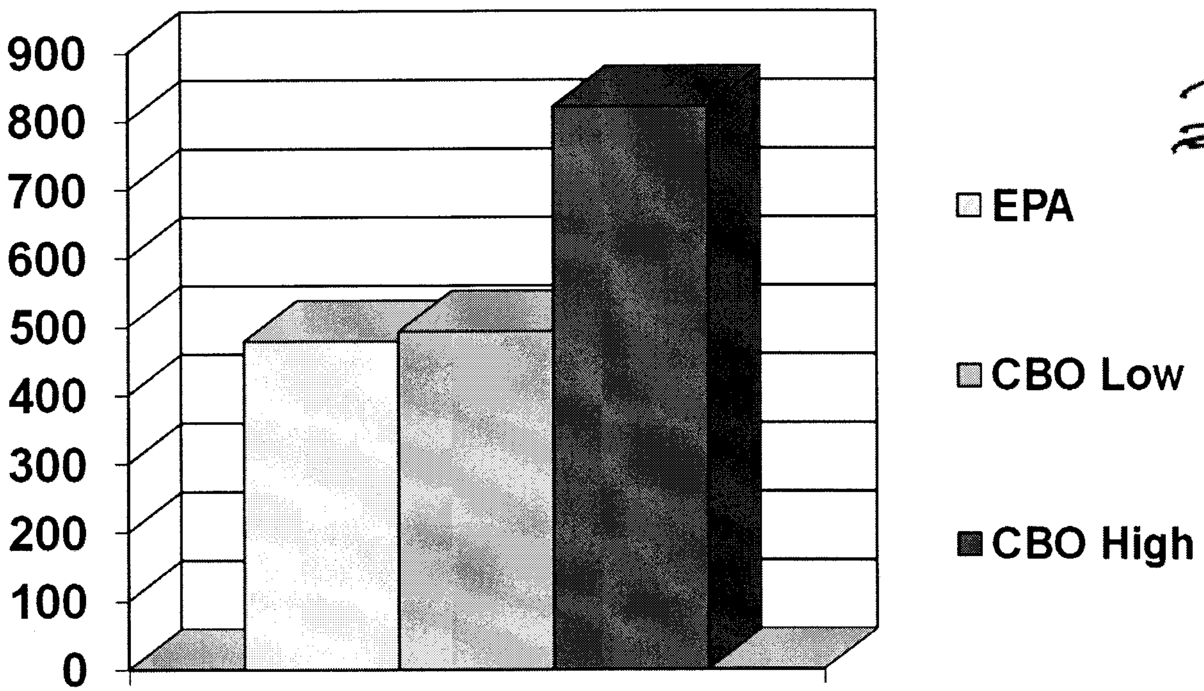
20-Year Infrastructure Investment Needs

($ Billions)



Congressional Research Service

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Annual O&M Estimate

Water

$25.7 to $31.8 Billion

Congressional Research Service

Wastewater

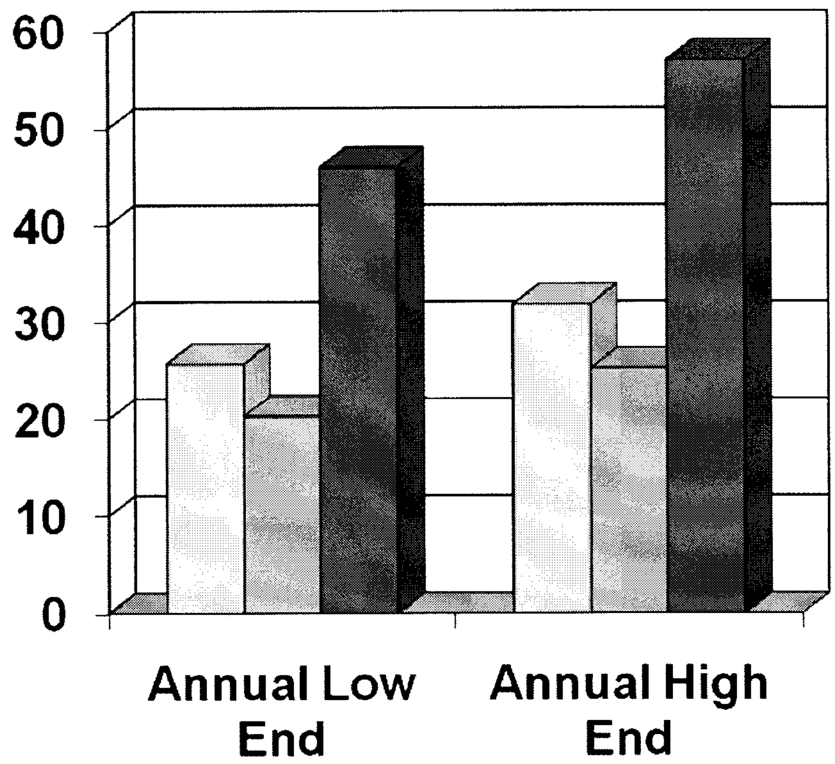
$20.3 to $25.2 Billion

ANNUAL O&M TOTAL: $46.0 to $57.0 Billion

U.S. Congressional Research Service, "Water Infrastructure Needs and Investment: Review and Analysis of Key Issues", November 24, 2008

Annual O&M Estimates

($ Billions)



Congressional Budget Office

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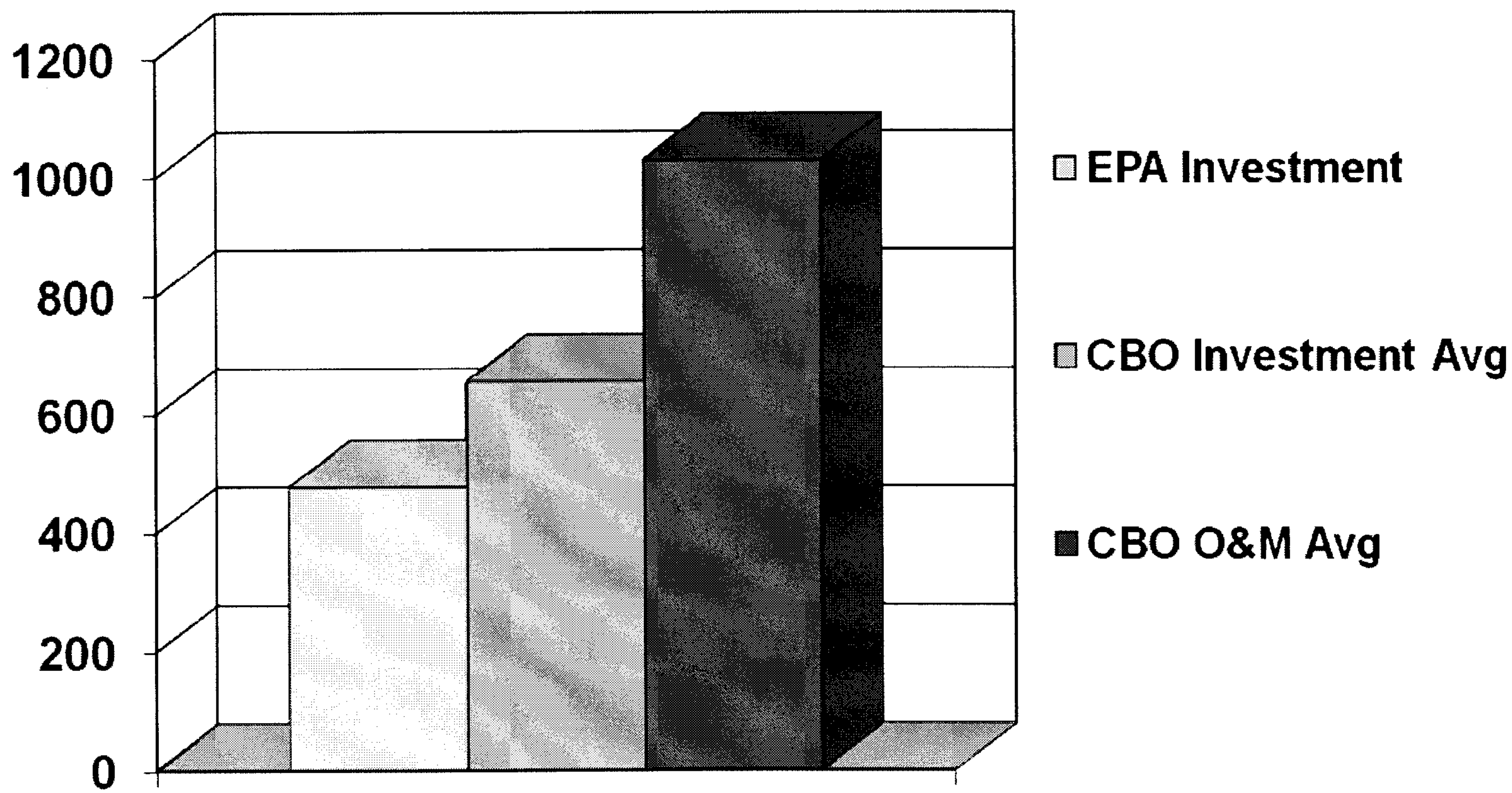
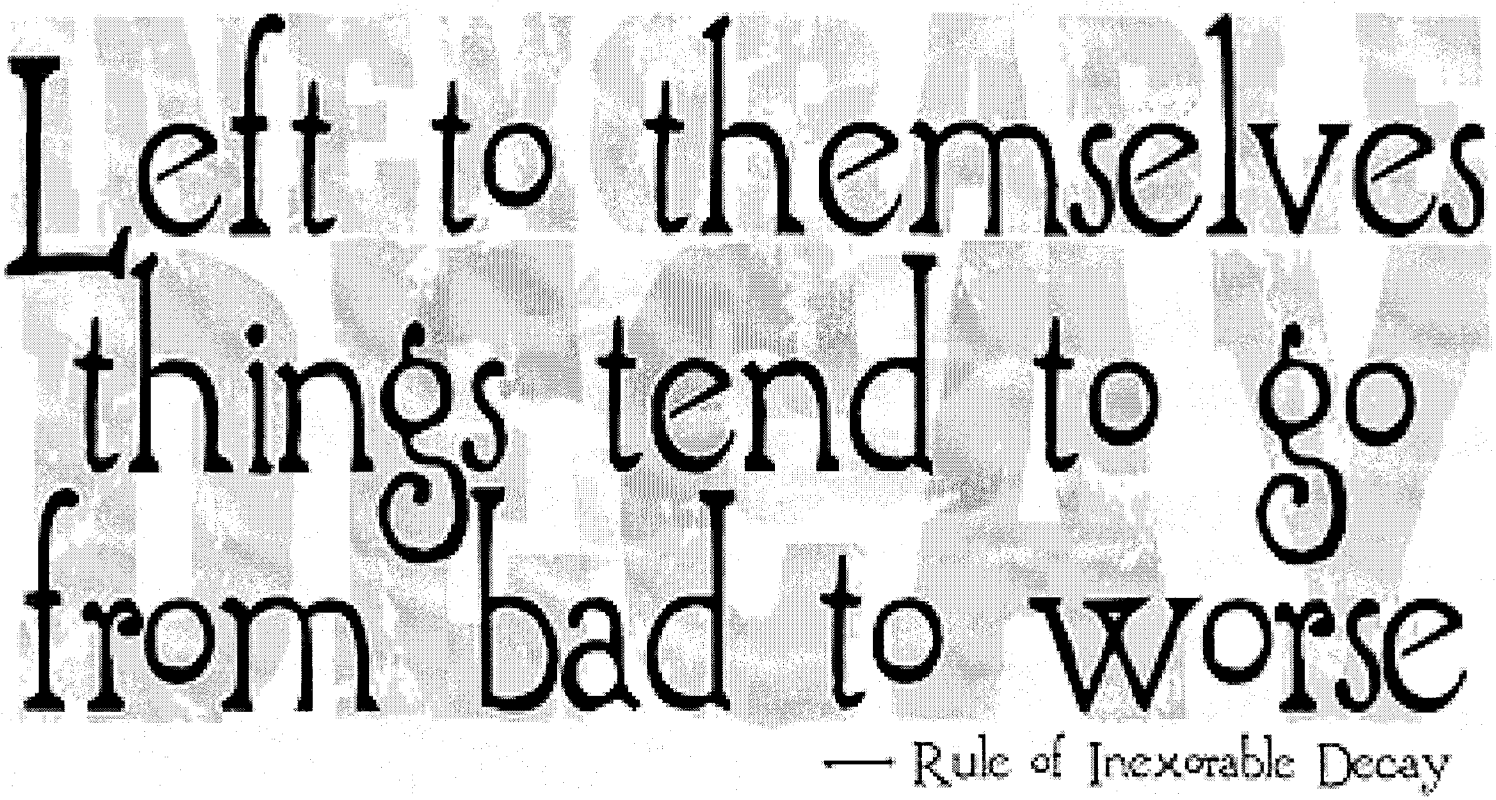
Investment vs. O&M
20 – Year Totals

($ Billions)



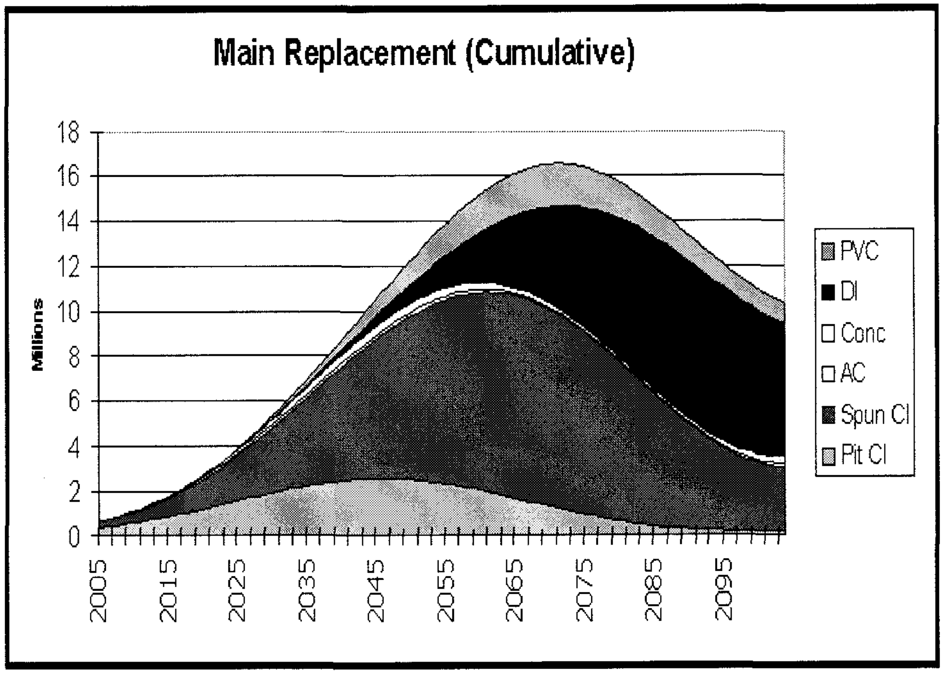
O&M could become a Bigger Issue than Replacement



DSICs Reduce O&M Expense

Fewer line breaks,
Fewer outages,
Avoiding major repairs.

DSICs Encourage Investment



Smoothing the investment path,

Decreasing regulatory lag,

Replacing aging infrastructure.

Image: American Water Works Association

1999 Water Task Force Report

- “RUCO agrees that [a DSIC], if properly designed, has the potential to promote the upgrading of deteriorating water systems, without harmful or biased rate impacts on customers.”

- “Commission Staff is not opposed to implementing a policy similar to Pennsylvania’s DSIC.” Page 18

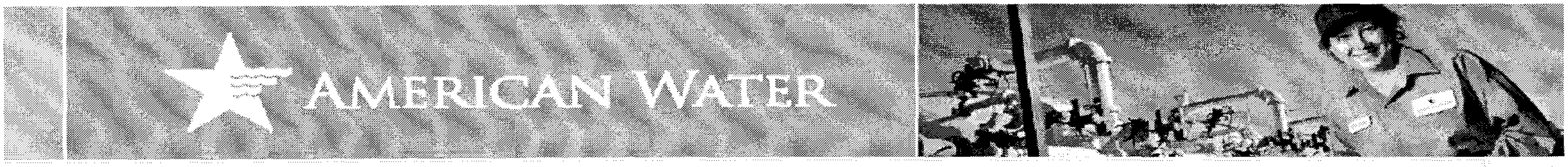
Benefits of DSICs

- Less “rate shock”
  - plant additions phase into rate base instead of coming in one major rate hike,
- Healthier utilities
  - authorized returns are more likely to be earned,
- Reduced water loss
  - pipes are replaced, mains are relined

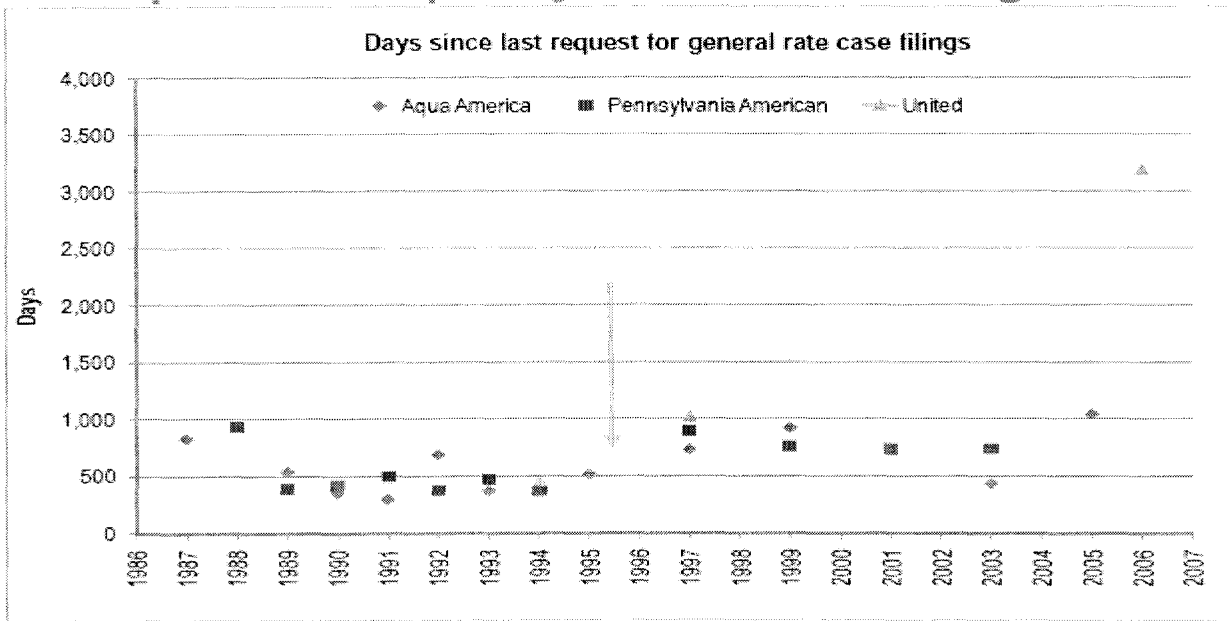
Benefits of DSICs

- Higher quality and more reliable systems,
- A tendency toward longer periods between rate cases, and
- A dedicated investment pool for replacements.

Benefits of DSICs



Focus on Pennsylvania:
Potential Impact on Frequency of Rate Case Filings



(Source: Presentation of Dr. Jan Beecher, Executive Director, Institute for Public Utilities, Michigan State University, to the 2008 Eastern NARUC Water Committee Rate School)

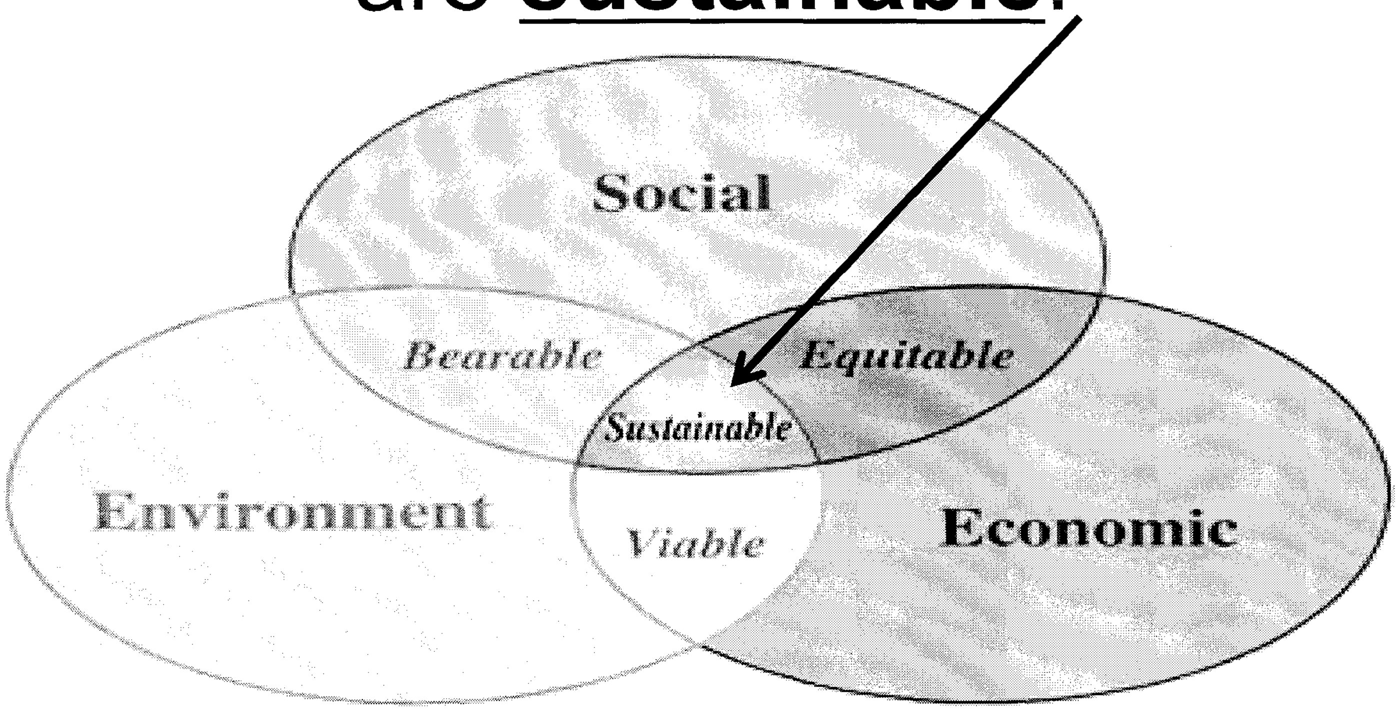
www.amwater.com

What Arizona can Gain with DSICs

- Annual, bearable changes to rates - decreasing “rate shock” and rate case frequency,
  - (Social Benefit)
- More modern, more efficient infrastructure,
  - (Environmental Benefit)
- Healthier water and wastewater companies,
  - (Economic Benefit).

The Triple Bottom Line in Economics…

Socially responsible, *environmentally* sound, *economically* beneficial programs are **sustainable**.



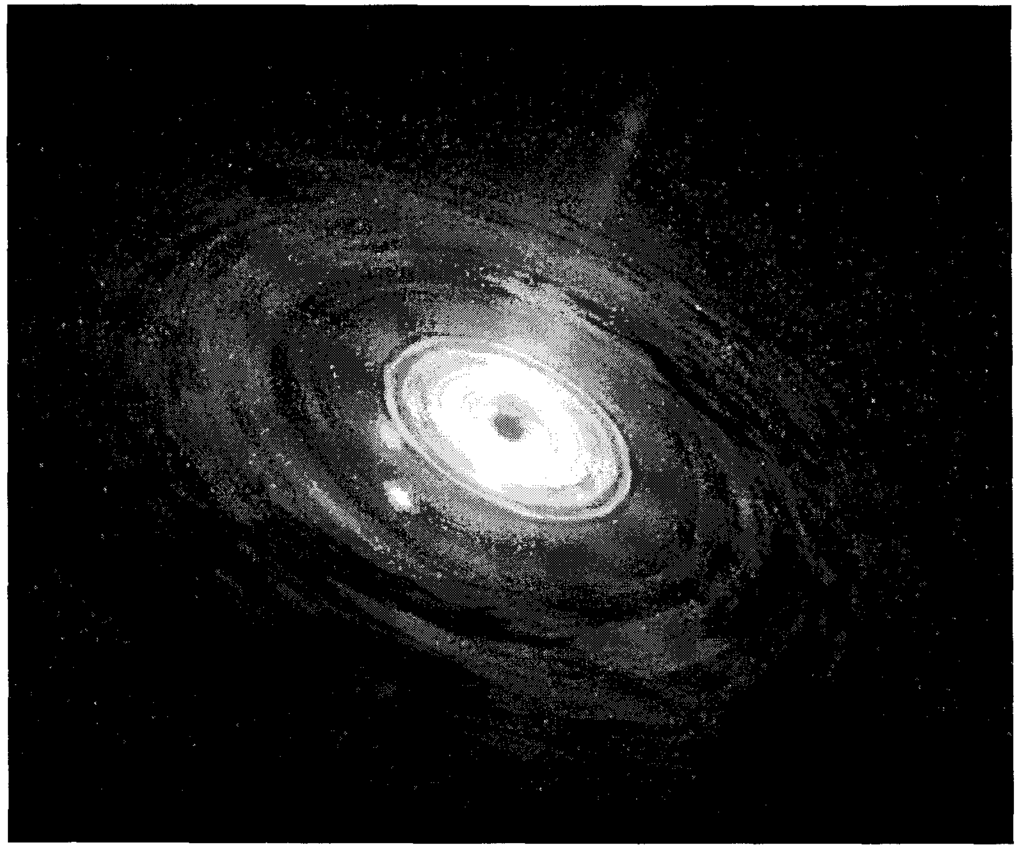
University of Maryland, Sustainability Program

Caveat on DSICs

Negative Rate Base Companies Cannot be helped with DSIC

Under current ACC policy, utilities with a negative rate base are not eligible to earn a return on new incremental investments.

There is NO way out of a black hole.

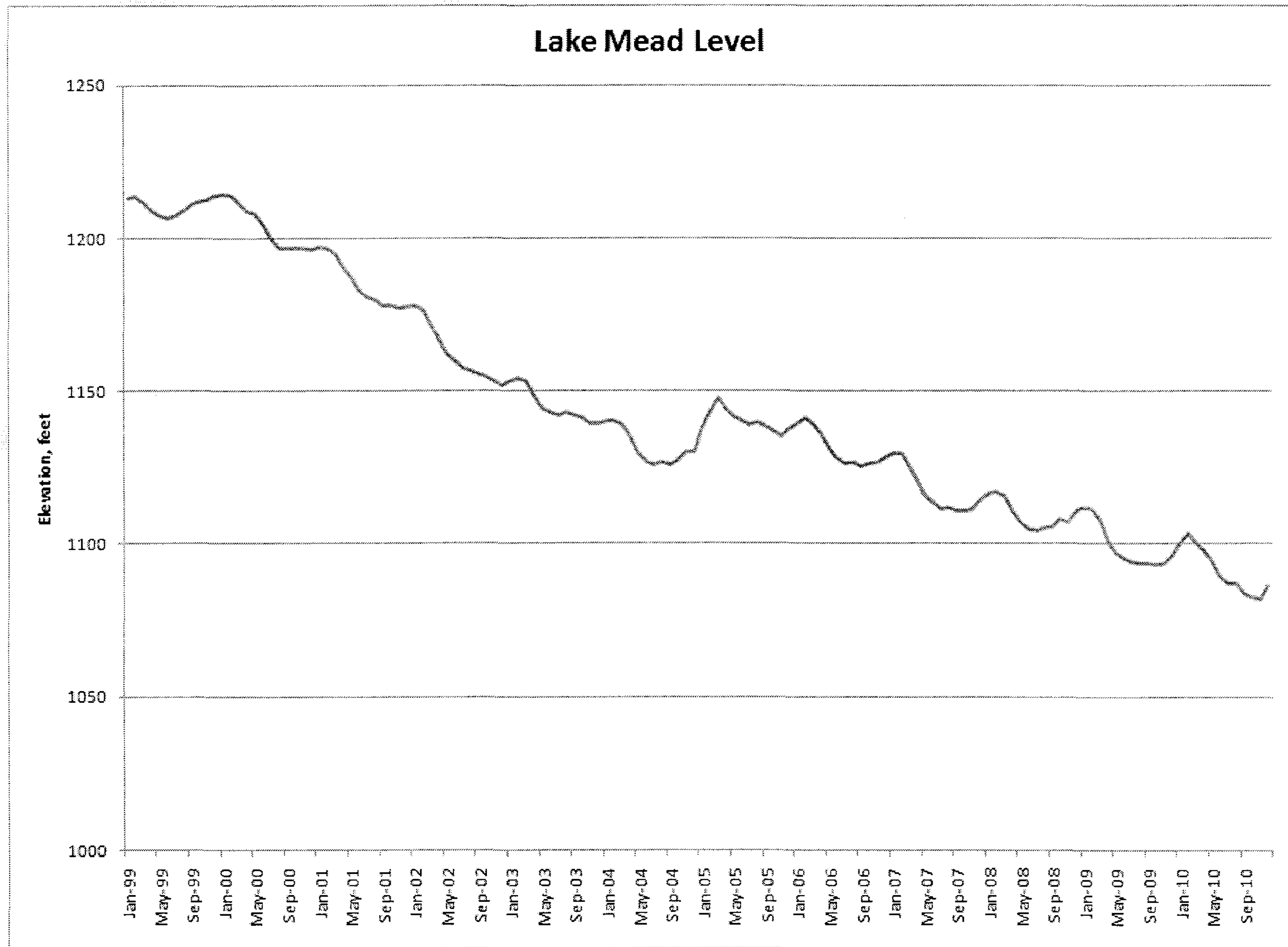


DSICs, Water Loss and Human Health

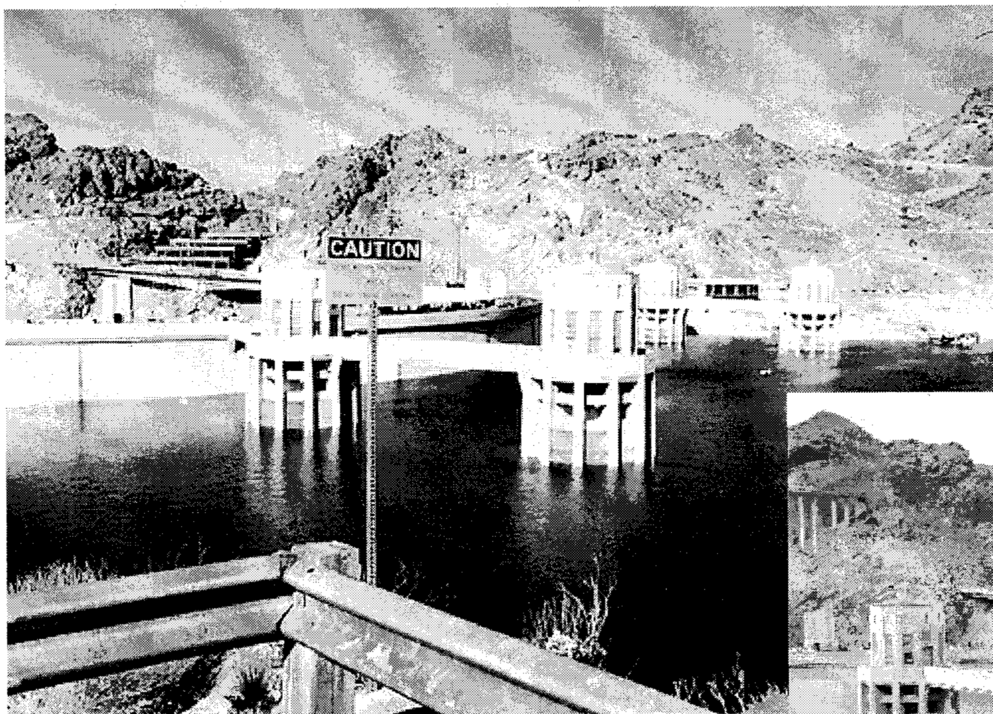
Graham Symmonds
Global Water

GLOBAL WATER

GLOBAL WATER



US Bureau of Reclamation, LAKE MEAD AT HOOVER DAM, ELEVATION (FEET)
http://www.usbr.gov/lc/region/g4000/hourly/mead-elv.html accessed 4 Jan 11.


CAUTION

Distribution System Health

- Function of:
  - Age
    - Increasing
  - Water quality
    - pH, hardness, iron, manganese, etc
  - Soil characteristics
    - pH, corrosivity etc
  - Pipe material
    - Wood, cast iron, lead, ductile iron, AC, PVC etc
  - Pressure & Flow
    - High pressure, transients etc

75,000 Sanitary Sewer Overflows

Wastewater Collection Systems

- 3–10 billion gallons of untreated wastewater discharged annually.
- up to 3,700 illnesses annually are due to exposure to recreational water contaminated by sanitary sewer overflows.
- In 1989, sanitary sewer overflows in Cabool, Missouri, contaminated drinking water distribution lines, causing 243 cases of diarrhea and 4 deaths.
- In 1993, direct contact with a discharge of untreated sewage in Ocoee, Florida, resulted in 39 cases of hepatitis A.

USEPA, Addressing the Challenge Through INNOVATION, Office of Research and Development National Risk Management Research Laboratory

240,000 water main breaks
1.7 trillion gallons lost per year

Drinking Water Distribution systems

- The number of breaks increases substantially near the end of the system's service life.
- Large utility breaks in the Midwest increased from 250 per year to 2,200 per year during a 19-year period.
- In 2003, Baltimore, Maryland, reported 1,190 water main breaks (> 3/day).
- National cost of $2.6 billion per year.

USEPA, Addressing the Challenge Through INNOVATION, Office of Research and Development National Risk Management Research Laboratory

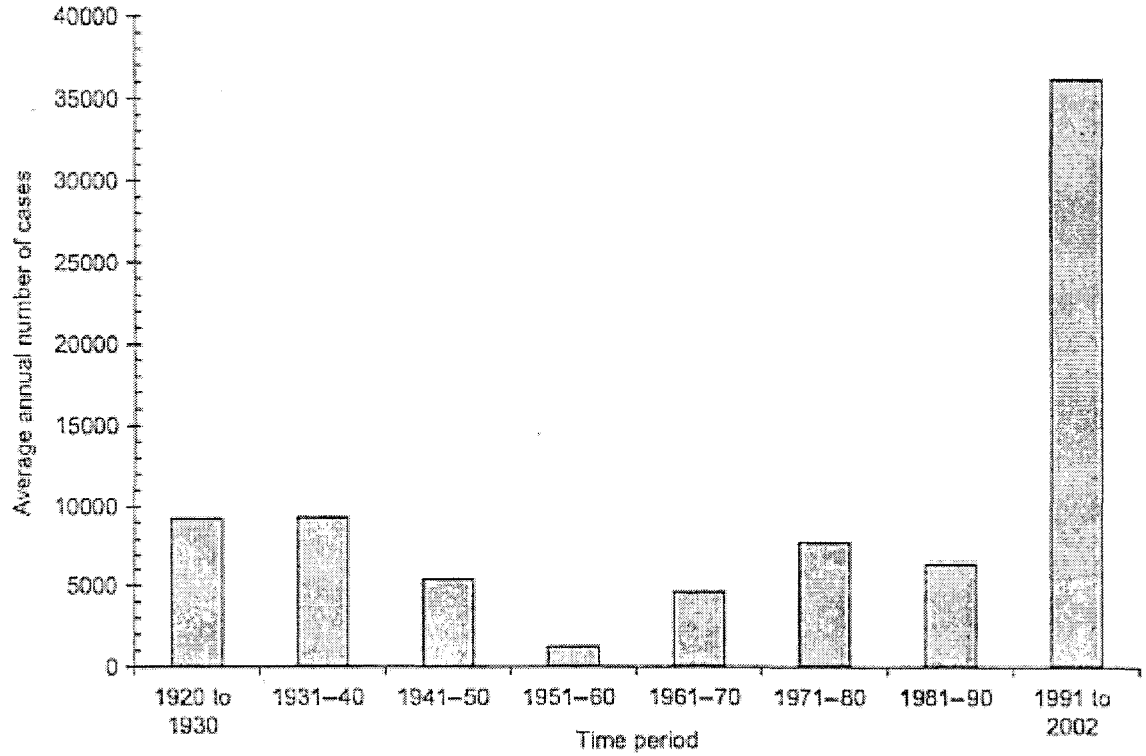
GLOBAL WATER

Water Loss

- 1.7 trillion gallons per year (USGS)
  = 5.2 million acre-feet
- Lake Mead holds 28.537 million acre-feet (at elevation 1221.4 ft) (BOR)

Distribution systems lose the equivalent of Lake Mead every 5 years

Water-Borne Disease Outbreaks

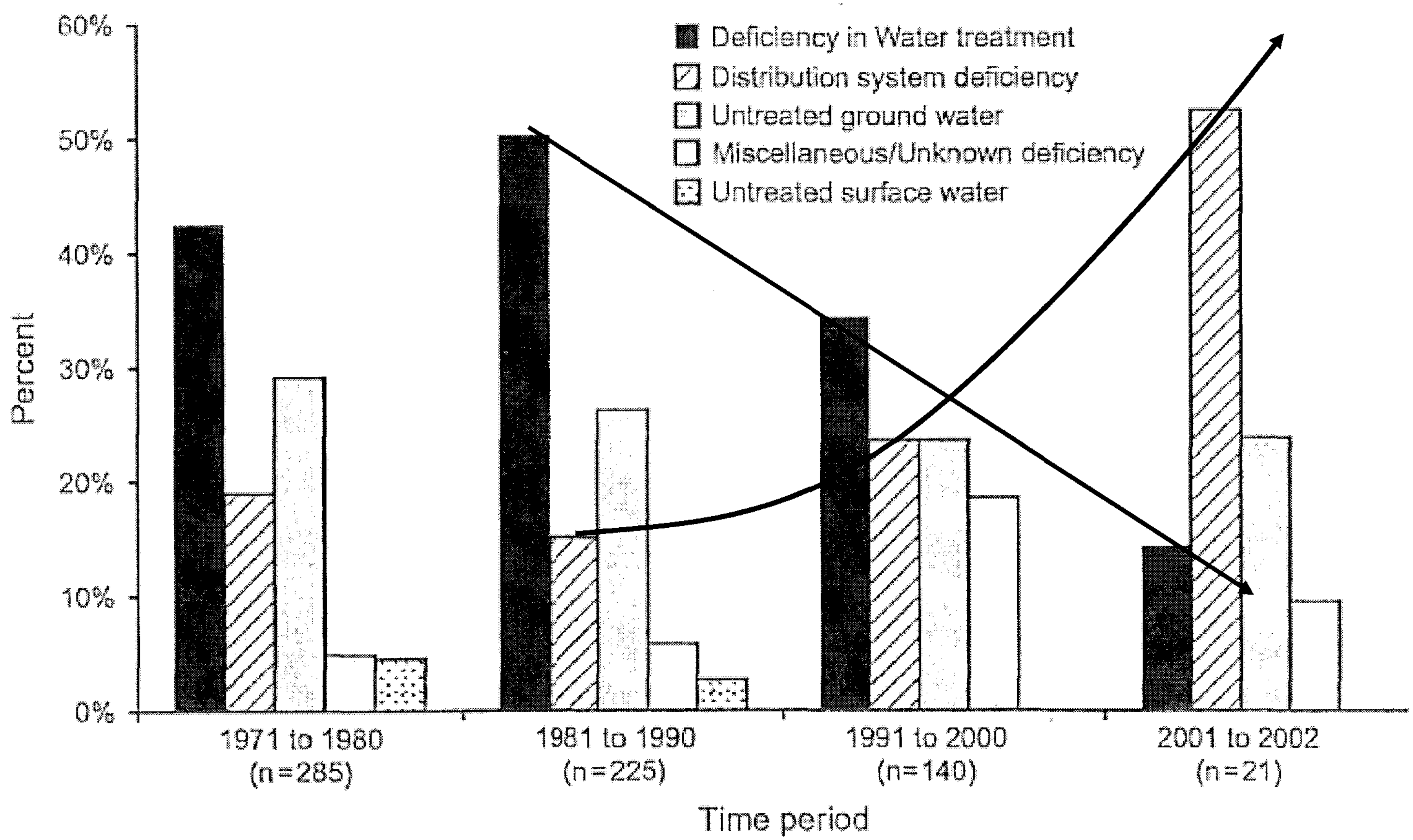


M.F. Craun, et al., Waterborne outbreaks reported in the United States, J. Wat. Health 4(Suppl. 2), 19–30, 2006.

Distribution Systems

- Out of sight, out of mind
- SDWA regulates 91 contaminants
- SDWA is based on regulating water delivered to the distribution system (point of compliance is the EPDS)
  - Only 3 rules require monitoring in the distribution system:
    - LCR
    - TCR
    - D/DBPR

Sources of Water-Borne Disease Outbreaks



M.F. Craun, et al., Waterborne outbreaks reported in the United States, J. Wat. Health 4(Suppl. 2), 19–30, 2006.

Incidents of Water-Borne Disease Outbreaks

- Very strong association of water-borne disease outbreaks with reporting of loss of pressure at the home tap.
- Most of the reported episodes of pressure loss were associated with disruption of the water supply and are likely to be related to burst water mains.

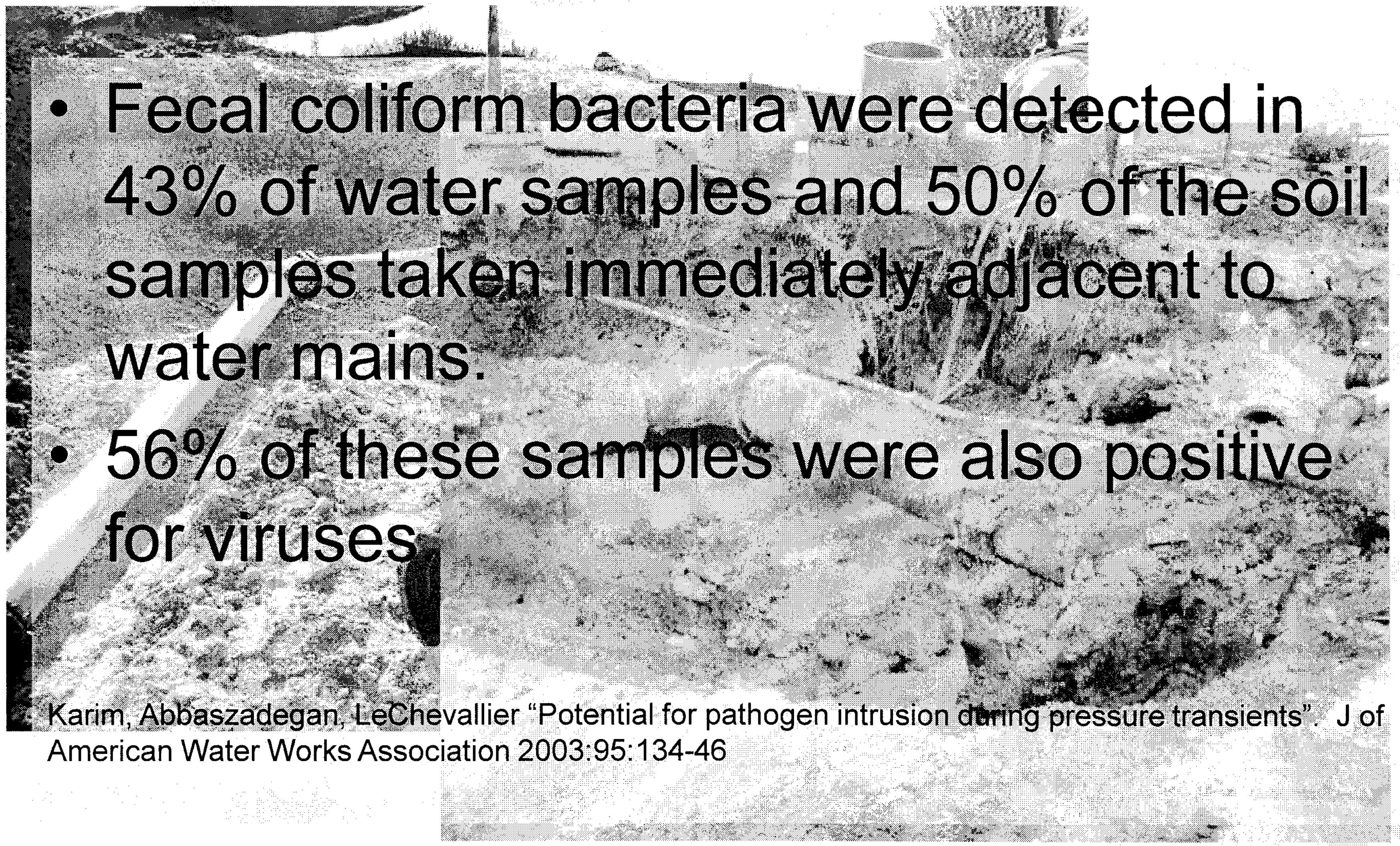
Paul R. Hunter et al., Self-Reported Diarrhea in a Control Group: A Strong Association with Reporting of Low-Pressure Events in Tap Water, Clinical Infectious Diseases 2005; 40:e32–4

Why?

Why?

GLOBAL WATER

Why?



- Fecal coliform bacteria were detected in 43% of water samples and 50% of the soil samples taken immediately adjacent to water mains.
- 56% of these samples were also positive for viruses

Karim, Abbaszadegan, LeChevallier “Potential for pathogen intrusion during pressure transients”. J of American Water Works Association 2003:95:134-46

DSICs

- Provide a regulatory incentive to institute a management program
- Encourages best management practices and collection system/distribution system optimization
- Overall decrease in emergency O&M
- Overall decrease in instantaneous CAPEX

Regulatory Constructs to Ensure Efficiency

- Metrics:
  - Main failures per mile
  - Sewer overflows
  - Water Loss
    - GPHMI
    - Approach UARL
  - Outages
    - SAIDI/SAIFI
    - CAIDI/CAIFI

Regulatory Constructs to Ensure Efficiency

- SAIDI/SAIFI
  - System Average Interruption Duration Index

$$\mathrm{SAIDI} = \frac{\text{sum of all customer interruption durations}}{\text{total number of customers served}}$$

  - System Average Interruption Frequency Index

$$\mathrm{SAIFI} = \frac{\text{total number of customer interruptions}}{\text{total number of customers served}}$$

- CAIDI/CAIFI
  - Customer Average Interruption Duration Index

$$\mathrm{CAIDI} = \frac{\text{sum of all customer interruption durations}}{\text{total number of customer interruptions}} = \frac{\mathrm{SAIDI}}{\mathrm{SAIFI}}$$

  - Customer Average Interruption Frequency Index

$$\mathrm{CAIFI} = \frac{\text{total number of customer interruptions}}{\text{total number of customers who had at least one interruption}}$$


BOIL WATER
ORDER ISSUED

Arizona Corporation Commission
Water Finance Workshop
January 14, 2011

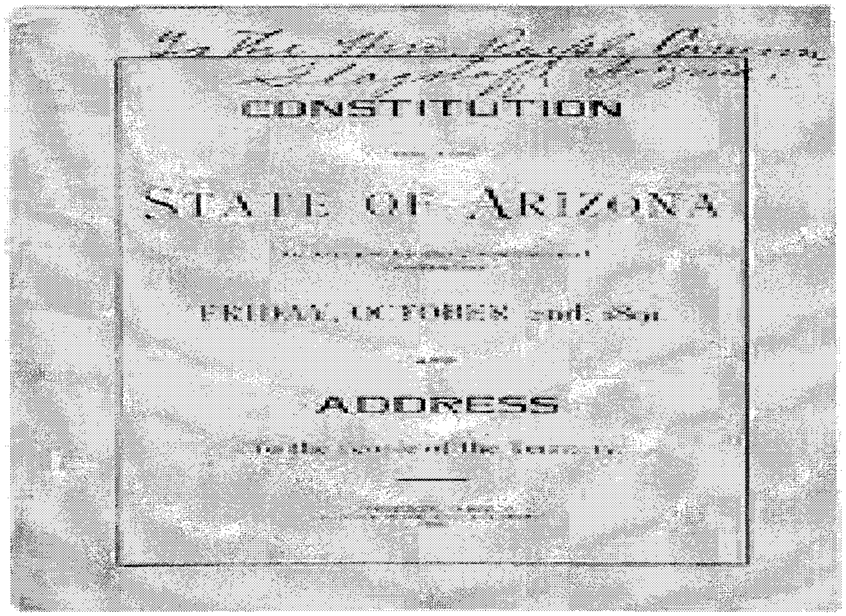
DSIC Legal Overview

Timothy J. Sabo
Roshka DeWulf & Patten PLC

Legal Requirements – DSIC Arizona Constitution

Article 15 Section 3

"Just and reasonable rates and charges"



DSIC Legal Requirements
Arizona Constitution

Article 15 Section 14 – Fair Value

"The Corporation Commission shall, to aid it in the proper discharge of its duties, ascertain the fair value of the property within the State of every public service corporation doing business therein"

DSIC Legal Requirements
Legal Precedent – Fair Value

- Simms v. Round Valley Light & Power Company
  - Fair Value must be used as rate base
  - "The reasonableness and justness of the rates must be related to this finding of fair value"
  - Citation = 80 Ariz. 145, 294 P.2d 378 (1956)

DSIC Legal Requirements
Legal Precedent – Fair Value

- RUCO v. ACC (Rio Verde)
  - Adjustment Mechanism must be in place before any surcharges granted
  - Prior case (*Scates*) "envisions the automatic adjustment clause as part of the utility's overall rate structure, which can be set only after a full rate hearing"
  - Citation = 199 Ariz. 588, 20 P. 3d 1169 (Ct. App. 2001)(Paragraphs 19-21)

Procedural Methods to approve DSIC mechanism

- ☐ Option 1 – Rate Case
- ☐ Option 2 – Policy Statement or Generic Docket
- ☐ Option 3 - Rule

DSIC Procedural Option 1
Rate Case

- Concept – utility applies for a DSIC in a rate application; treats DSIC similar to other adjuster mechanisms
  - Recent Arizona-American and AWC Applications
- ACC may establish model DSIC or guidelines in a policy statement or test case
- ACC Precedent – Arsenic Cost Recovery Mechanism (ACRM), first approved in Decision No. 66400 (Oct. 14, 2003)(Arizona Water Co., Northern Group)

DSIC Procedural Option 2
Policy Statement or Generic Docket

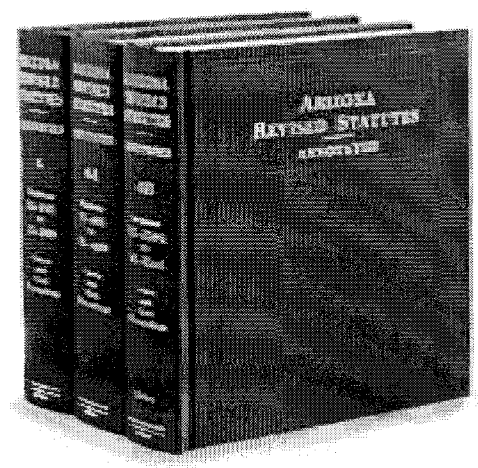
- Concept - DSIC mechanism established by substantive policy statement or order in generic docket
- ACC Precedent – Adoption of Rolling Average PGA Mechanism
  - Adopted, Decision No. 61225 (Oct. 30, 1998)
  - Implemented, June 1999
  - Modified, Decision No. 62994 (Nov. 3, 2000)
- Legal Issue – is this option still viable after RUCO v. ACC?

DSIC Procedural Option 3 Rule

- Concept – ACC adopts rule authorizing DSIC; companies then make filings contemplated by rule
- ACC Precedent
  - Sales Tax Pass Through
    - AAC R14-2-409(D)(5)
  - Renewable Energy Surcharge Tariff, AAC
    - AAC R14-2-1808

Conclusions

- ☐ DSIC legally similar to other adjustor mechanisms and surcharges
- ☐ DSIC can be implemented legally
- ☐ 3 procedural options



EPA

www.epa.gov

AGING WATER INFRASTRUCTURE
RESEARCH PROGRAM

Addressing the Challenge Through INNOVATION

Office of Research and Development
National Risk Management Research Laboratory

EPA

AGING WATER INFRASTRUCTURE RESEARCH PROGRAM

"Our nation's extensive water infrastructure has the capacity to treat, store, and transport trillions of gallons of water and wastewater per day through millions of miles of pipelines. However, as our infrastructure deteriorates, there are increasing concerns about the ability of this infrastructure to keep up with our future needs.

As part of our effort to address these concerns . . . ORD initiated a new water infrastructure research program. This program will generate the science and engineering needed to evaluate promising, innovative technologies to repair existing and provide new water infrastructure, and that improve effectiveness at reduced cost."

Statement of George Gray, Ph.D.
Assistant Administrator
Office of Research and Development (ORD)
United States Environmental Protection Agency
March 14, 2007

Drinking Water Distribution Systems

- There are 240,000 water main breaks per year in the United States.
- The number of breaks increases substantially near the end of the system's service life.
  - Large utility breaks in the Midwest increased from 250 per year to 2,200 per year during a 19-year period.
  - In 2003, Baltimore, Maryland, reported 1,190 water main breaks—that's more than three per day.
- A 2005 British study correlated self-reported diarrhea with low water-pressure events (including water main breaks).
- The U.S. Geological Survey estimates that water lost from water distribution systems is 1.7 trillion gallons per year at a national cost of $2.6 billion per year.

Wastewater Collection Systems

- There are up to 75,000 sanitary sewer overflows per year in the United States, resulting in the discharge of 3–10 billion gallons of untreated wastewater.
- Up to 3,700 illnesses annually are due to exposure to recreational water contaminated by sanitary sewer overflows.
- In 1989, sanitary sewer overflows in Cabool, Missouri, contaminated drinking water distribution lines, causing 243 cases of diarrhea and 4 deaths.
- In 1993, direct contact with a discharge of untreated sewage in Ocoee, Florida, resulted in 39 cases of hepatitis A.

The Aging Water Infrastructure (AWI) research program is part of EPA's larger effort called the Sustainable Water Infrastructure (SI) initiative. The SI initiative brings together drinking water and wastewater utility managers; trade associations; local watershed protection organizations; and federal, state, and local officials to ensure that all components of our nation's water infrastructure—drinking water treatment plants, drinking water distribution lines, sewer lines, and storage facilities—meet future needs.

The AWI research program supports the four priority areas of the SI initiative's strategy:

- Better management – Moving beyond compliance to sustainability and improved performance
- Full-cost pricing – Helping utilities to recognize the full cost of providing service over the long term
- Water efficiency – Promoting water efficiency in the residential and commercial sectors
- The watershed approach – Integrating watershed management principles and tools into utility planning and management practices

The Gap Analysis

A driving force behind the SI initiative and the AWI research program is the "Clean Water and Drinking Water Infrastructure Gap Analysis." In this report, EPA estimated that if operation, maintenance, and capital investment remain at current levels, the potential funding shortage for drinking water and wastewater infrastructure could exceed $500 billion by 2020. This funding gap could narrow with the application of innovative technologies and management practices.

Top Priority

A sustainable water infrastructure is among the top four priorities of EPA Administrator Stephen L. Johnson for these reasons:

- Our drinking water and wastewater systems are aging. Some components are more than 100 years old.
- The U.S. population is increasing and shifting geographically. This requires investment in new infrastructure for growth areas.
- Current treatment may not be sufficient to address emerging issues and changing regulatory requirements.

The Research Program

The AWI research program has identified the critical research needs related to our aging drinking water and wastewater infrastructure. EPA will work with collaborators and stakeholders to conduct technology research, development, and demonstration projects to fill the identified research gaps. Research projects will fall into four main areas:

Condition Assessment To assess the condition of a drinking water distribution or wastewater collection system, data and information are gathered through observation, direct inspection, investigation, and indirect monitoring and reporting. An analysis of the data and information helps determine the structural, operational, and performance status of capital infrastructure assets. Condition assessment also includes failure analysis to determine the causes of infrastructure failures and to develop ways to prevent future breakdowns. Condition assessment enhances the ability of utilities to make technically sound judgments regarding asset management.

System Rehabilitation System rehabilitation is the application of infrastructure repair, renewal, and replacement technologies in order to reinstate functionality in a drinking water or wastewater system or subsystem. The proper balance of the repair, renewal, and replacement depends on the condition assessment, the life-cycle costs of various rehabilitation options, and the related risk reductions.

Advanced Concepts Developing advanced concepts relates to the application of innovative infrastructure designs, management procedures, and operational approaches. The infusion of these advanced concepts into an established system is especially challenging; for example, the innovative concept could be a retrofit solution, but compatibility with the in-place system is critical. Advanced concepts *go beyond asset management* to include maximizing the benefits from low-impact development, water reuse, source water protection, and watershed management.

Innovative Treatment Technologies for Wastewater and Water Reuse These technologies address the dynamic requirements for improved water quality and the growing demand for safe and reliable reclaimed wastewater and storm water. For example, wet-weather flows at water treatment plants must be managed more effectively in order to reduce pathogen content. And there are new challenges relating to the capability of pharmaceuticals and personal care products to interfere with, and even inhibit, the wastewater treatment process. Controlling nitrogen and phosphorous is a growing priority, especially in the basins that drain into the Mississippi River, the Great Lakes, and the Chesapeake Bay. In Florida, California, and the arid Southwest, the use of reclaimed wastewater and storm water is rapidly increasing. There is accelerated demand for wastewater treatment technologies to be more energy efficient and to produce smaller volumes of residuals.

Projects under the AWI research program include technology demonstrations; state-of-the-technology assessments; applied research; field applications; basic research; and bench-scale, pilot-scale, and controlled-condition testing. The projects will focus on:

- Optimizing repair, rehabilitation, and replacement
- Extending the service life of installed drinking water and wastewater system components
- Reducing system failures and their adverse effects on public health and the environment
- Reducing sewer overflows and backups
- Evaluating the performance and cost of innovative technologies and approaches
- Investigating advanced system design and management concepts

- Detecting, locating, and characterizing leaks in drinking water distribution and wastewater collection systems
- Designing systems with a green infrastructure and low-impact development components to attenuate wastewater flows
- Reducing high-risk water main and force main breaks

A Sustainable Water Infrastructure Tomorrow Means Fundamental Change Today

The AWI research program is bringing about that change. Using the program's technical strength and unbiased information, EPA is helping reduce the cost and improve the effectiveness of our aging—and failing—drinking water and wastewater treatment and conveyance systems. Existing technologies need to be applied in unconventional ways. Emerging technologies and innovative thinking will be at the forefront of creating a powerful, secure, and reliable water infrastructure.

Outcomes

Near-term outcomes will be technology reports on *condition assessment* (inspection technologies), rehabilitation (service laterals, liners), and advanced system designs. In the long term, guidance documents will be developed on asset management, real-time monitoring, new materials, verification and demonstration of innovative technologies, and sustainable management and design approaches.

Our drinking water and wastewater systems are aging. Some components are more than 100 years old.

AGING WATER INFRASTRUCTURE RESEARCH PROGRAM

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The Door Is Open for Collaboration

EPA, whose primary role is that of advocate for a sustainable water infrastructure, is only one partner in this effort. The AWI research program presents opportunities for utilities, vendors, researchers, academics, water associations (trade and professional), and other agencies and organizations to collaborate. In fact, the success of the program depends on stakeholder involvement, sharing information and tools, and working together toward the long-term stewardship of our water infrastructure.

EPA INVITES YOU TO PARTICIPATE BY CONTACTING:

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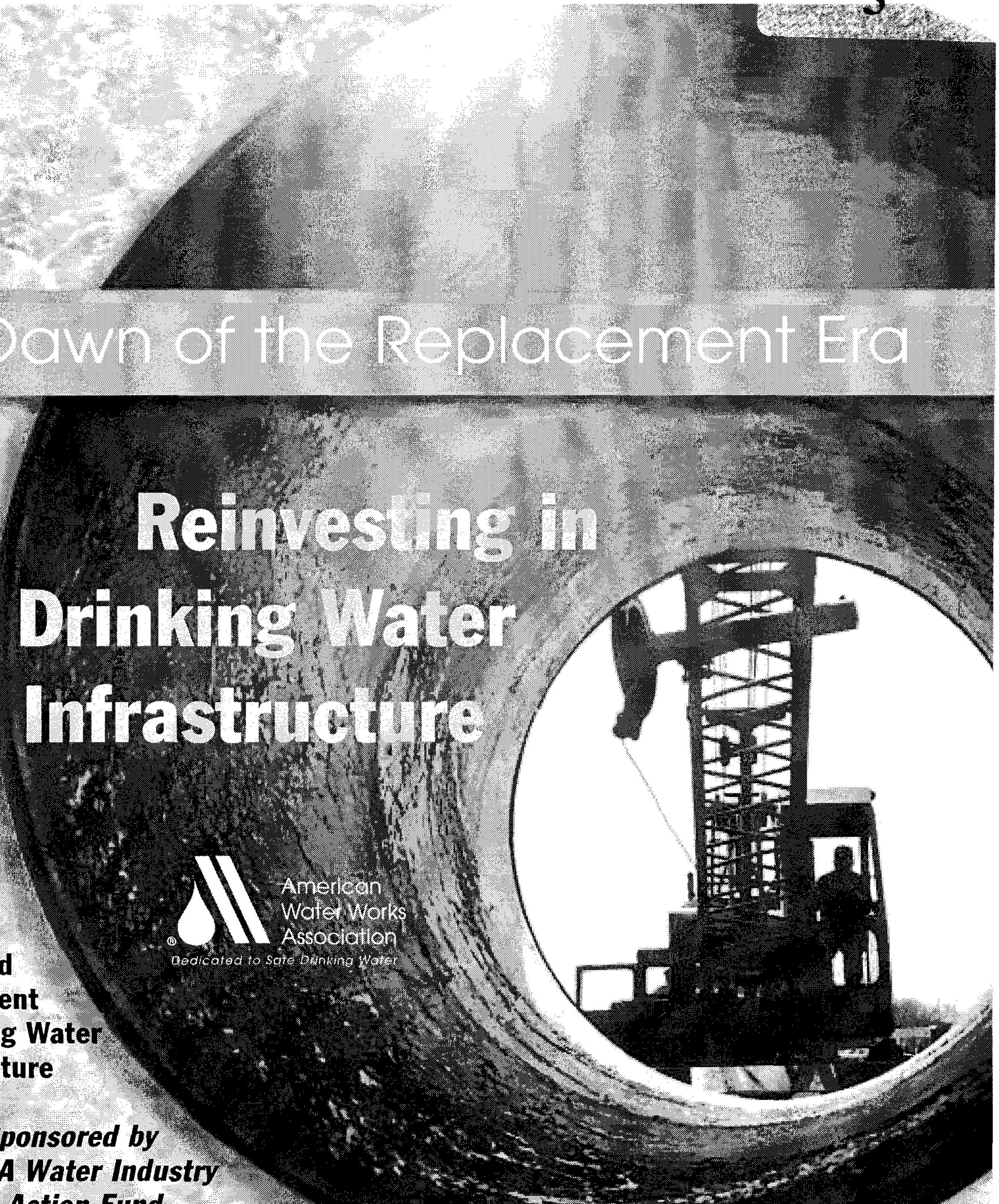
Dawn of the Replacement Era

Reinvesting in Drinking Water Infrastructure



American Water Works Association
Dedicated to Safe Drinking Water

An Analysis of Twenty Utilities' Needs for Repair and Replacement of Drinking Water Infrastructure

A Study Sponsored by The AWWA Water Industry Technical Action Fund

May 2001

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Reinvesting in Drinking Water Infrastructure

Dawn of the Replacement Era

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Dawn of the Replacement Era

EXECUTIVE SUMMARY

The importance of safe drinking water to public health and the nation's economic welfare is undisputed. However, as we enter the 21st Century, water utilities face significant economic challenges. For the first time, in many of these utilities a significant amount of buried infrastructure—the underground pipes that make safe water available at the turn of a tap—is at or very near the end of its expected life span. The pipes laid down at different times in our history have different life expectancies, and thousands of miles of pipes that were buried over 100 or more years ago will need to be replaced in the next 30 years. Most utilities have not faced the need to replace huge amounts of this infrastructure because it was too young. Today a new age has arrived. We stand at the dawn of the replacement era.

Extrapolating from our analysis of 20 utilities, we project that expenditures on the order of $250 billion over 30 years might be required nationwide for the replacement of worn-out drinking water pipes and associated structures (valves, fittings, etc). This figure does not include wastewater infrastructure or the cost of new drinking water standards. Moreover, the requirement hits different utilities at different times and many utilities will need to accelerate their investment. Some will see rapidly escalating infrastructure expenditure needs in the next 10–20 years. Others will find their investment decisions subject to a variety of factors that cause replacement to occur sooner or at greater expense, such as urban redevelopment, modernization, coordination with other city construction, increasing pipe size, and other factors.

Overall, the findings confirm that replacement needs are large and on the way. There will be a growing conflict between the need to replace worn-out infrastructure and the need to invest in compliance with new regulatory standards under the Safe Drinking Water Act. In addition, the concurrent demands for investment in wastewater infrastructure and compliance with new Clean Water Act regulations, including huge needs for meeting combined sewer overflow (CSO) and stormwater requirements, will compete for revenue on the same household bill.

Ultimately, the rate-paying public will have to finance the replacement of the nation's drinking water infrastructure either through rates or taxes. AWWA expects local funds to cover the great majority of the nation's water infrastructure needs and remains committed to the principle of full-cost recovery through rates. However, many utilities may face needs that are large and unevenly distributed over time. They must manage a difficult transition between today's level of investment and the higher level of investment that is required over the long term. Facing an inexorable rise in infrastructure replacement needs driven by demographic forces that were at work as much as 100 years ago, compounded by the negative effects of changing demographics on per-capita costs in center cities, many utilities face a significant challenge in keeping water affordable for all the people they serve.

Meeting this challenge requires a new partnership in which utilities, states, and the federal government all have important roles. Utilities need to examine their rate structures to assure long-term viability. States need to streamline their programs. And the federal government needs to significantly increase assistance for utilities.

To better understand this problem, the American Water Works Association undertook studies of 20 large and medium utilities. The findings and recommendations of this report provide the basis for this new partnership to achieve the goal to which we all aspire—the provision of safe and affordable drinking water for all Americans.

Findings:

- Water utilities must make a substantial reinvestment in infrastructure over the next 30 years. The oldest cast iron pipes, dating to the late 1800s, have an average life expectancy of about 120 years. Because of changing materials and manufacturing techniques, pipes laid in the 1920s have an average life expectancy of about 100 years, and pipes laid in the post-World War II boom can be expected to last about 75 years. The replacement bill for these pipes will be hard on us for the next three decades and beyond.

- Most utilities are just now beginning to face significant investments for infrastructure replacement. Indeed, it would have been economically inefficient to make large replacement investments before now. The utilities we studied are well managed and have made the right decisions. But the bills are now coming due, and they loom large.

- On average, the replacement cost value of water mains is about $6,300 per household in today's dollars in the relatively large utilities studied. If water treatment plants, pumps, etc., are included, the replacement cost value rises to just under $10,000 per household, on average.

- Demographic shifts are a significant factor in the economics of reinvestment. In some older cities, the per-capita replacement value of mains is more than three times higher than the average in this sample due to population declines since 1950.

- By 2030, the average utility in the sample will have to spend about three and a half times as much on pipe replacement due to wear-out as it spends today. Even so, the average utility will also spend three times as much on repairs in that year as it spends today, as the pipes get older and more prone to breakage.

- The water utilities studied concurrently face the need to replace infrastructure and upgrade treatment plants to comply with a number of new regulations to be implemented under the Safe Drinking Water Act. Many municipalities also face significant needs for investments in wastewater infrastructure and compliance. This concurrent demand significantly increases the financial challenge they face.

- Overall, in the 20 utilities studied, infrastructure repair and replacement requires additional revenue totaling about $6 billion above current spending over the next 30 years. This ranges from about $550 per household to almost $2,300 per household over the period. These household impact figures do not include compliance with new regulations or the cost of infrastructure replacement and compliance for wastewater.

- The pattern and timing of the need for additional capital will be different in each community, depending on its demographically driven replacement "wave."
- Household impacts will be two to three times greater in smaller water systems ($1,100 to $6,900 per household over 30 years) due to disadvantages of small scale and the tendency for replacement needs to be less spread out over time.
- Because of demographic changes, rate increases will fall disproportionately on the poor, intensifying the challenge that many utilities face keeping water affordable to their customers.

Recommendations:

America needs a new partnership for reinvesting in drinking water infrastructure. There are important roles at all levels of government.

1) Measures by Utilities and Local Governments

Although the AWWA analysis has looked at the infrastructure issue in the aggregate, many key issues must be addressed at the local utility level. Utilities should develop a comprehensive local strategy that includes:

- Assessing the condition of the drinking water system infrastructure.
- Strengthening research and development
- Working with the public to increase awareness of the challenge ahead, assess local rate structures, and adjust rates where necessary.
- Building managerial capacity.

2) Reform of State Programs

The states too have an important role to play in addressing our infrastructure funding needs. States may need to match an appropriate share of any new federal funds that are provided for infrastructure assistance. Moreover, states need to reform their existing programs to make them more effective. States should commit to:

- Respecting the universal eligibility of all water systems for federal assistance.
- Streamlining their programs for delivery of assistance and allow alternative procurement procedures that save money.
- Making their financing mechanisms more attractive by committing to grants and very low or negative interest loans.
- Using federal funds in a timely fashion or face the reprogramming of those funds to other states.

3) A Significant Increase in Federal Assistance

The federal government has a critical role to play in preventing the development of a gap in water infrastructure financing. AWWA recommends either changing and expanding the existing Drinking Water State Revolving Fund and other drinking water programs, or creating a new, infrastructure-focused fund. The federal role should include:

- Significantly increased federal funding for projects to repair, replace, or rehabilitate drinking water infrastructure.
- An increase in federally supported research on infrastructure management, repair and replacement technologies.
- Steps to increase the availability and use of private capital.

Reinvesting in Drinking Water Infrastructure

Dawn of the Replacement Era

Introduction

The importance of safe drinking water to the nation's public health and economic welfare is undisputed. About 54,000 community drinking water systems provide drinking water to more than 250 million Americans. By keeping water supplies free of contaminants that cause disease, our public water systems reduce sickness and related health costs as well as absenteeism in the workforce. By providing safe and sufficient supplies of water, America's public water systems create direct economic value across nearly every sector of the economy and every region of the country. However, significant economic changes are confronting the water profession as we enter the 21st Century. The new century poses new challenges in sustaining the infrastructure—particularly the underground pipes—that provides the broad public benefits of clean and safe water.

Recognizing that we are at the dawn of a major change in the economics of water supply, the American Water Works Association (AWWA) has undertaken an analysis of the infrastructure challenge facing utilities. The project involved correlating the estimated life of pipes with actual operations experience in a sample of 20 utility systems geographically distributed throughout the nation (see Figure 1). Projecting future investment needs for pipe replacement in those utilities yields a forecast of the annual replacement needs for a particular utility, based on the age of the pipes and how long they are expected to last in that utility. This analysis graphically portrays the nature of the challenge ahead of us. It also serves as the foundation for AWWA's call for a new national partnership to address the looming need to reinvest in our drinking water infrastructure.

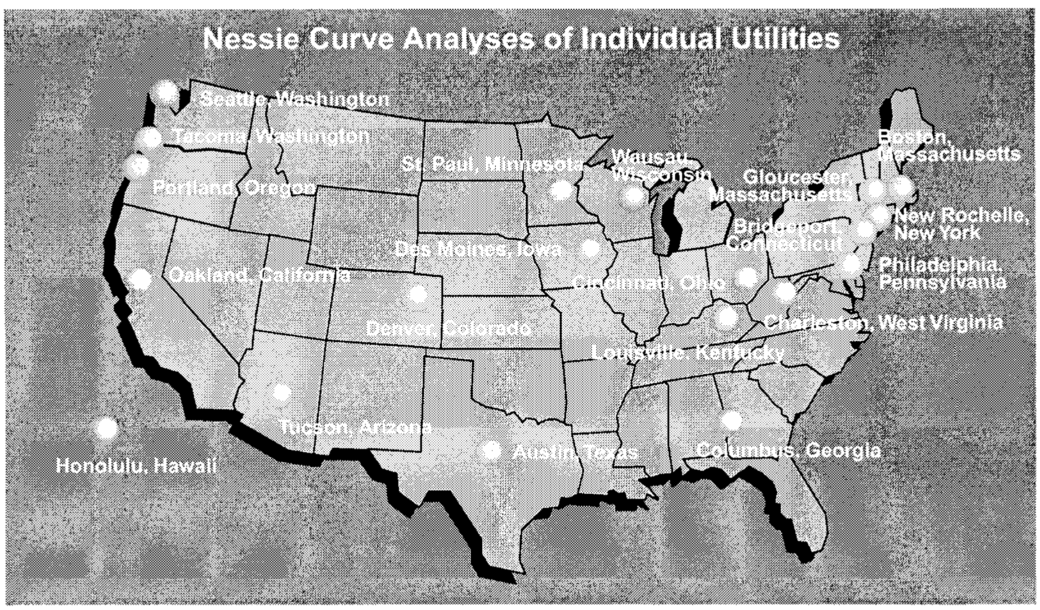


Figure 1

Pipes are expensive, but invisible.

Most people do not realize the huge magnitude of the capital investment that has been made to develop the vast network of distribution mains and pipes—the infrastructure—that makes clean and safe water available at the turn of a tap. Water is by far the most capital intensive of all utility services, mostly due to the cost of these pipes, water infrastructure that is literally a buried treasure beneath our streets. But buried means out of sight. And as the old saying goes, out of sight means out of mind. Moreover, most of our pipes were originally installed and paid for by previous generations. They were laid down during the economic booms that characterized the last century's periods of growth and expansion. So not only do we take these pipes for granted because we can't see them, we also take them for granted because, for the most part, we didn't pay for them initially. What's more, they last a long time (some more than a century) before they cost us very much in maintenance expense near the end of their useful lives or ultimately need replacement. For the most part, then, the huge capital expense of the pipes is a cost that today's customers have never had to bear. It has always been there, but it's always been invisible to us.

The original pattern of water main installation from 1870 to 2000 in 20 utilities analyzed by AWWA is graphically presented in Figure 2. This graph reflects the total cost in current dollars of replacing the pipes laid down between 1870 and 1998 in the 20 utilities studied. It is a reflection of the development of these utilities, and in turn, mirrors the overall pattern of population growth in large cities across the country. There was an 1890s boom, a World War I boom, a roaring '20s boom, and the massive post-World War II baby boom.

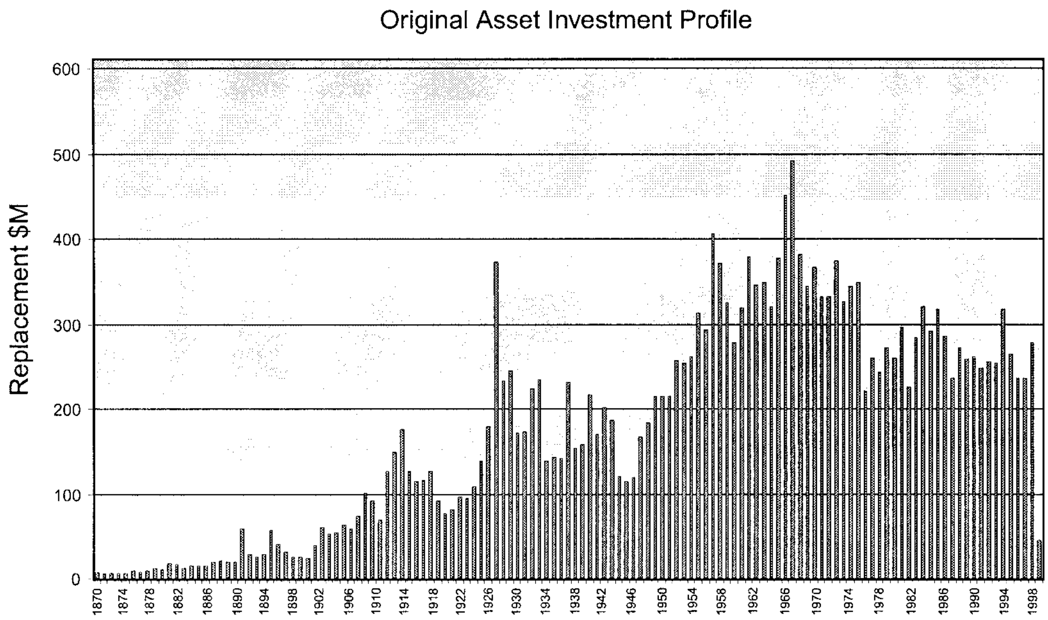


Figure 2

The cumulative replacement cost value of water main assets (that is, the cost of replacing water mains in constant year 2000 dollars) has increased steadily over the last century in our sample of 20 utilities. In aggregate across our sample of utilities, the replacement value of water mains in today's dollars is about $6,300 per household. If water treatment plants, pumps, etc., are included, this figure rises to just under $10,000 per household. This is more than three times what it was in 1930 in constant dollar terms. The difference is not due to inflation; rather, there is simply more than three times as much of this infrastructure today as there was in 1930, in order to support improved service standards and the changing nature of urban development.

In general, then, there is a lot more water infrastructure in place today on a per-capita basis, implying an increased per-capita share of the liability for replacing these assets as they wear out. This invisible replacement liability has been accumulating gradually over several generations of water system customers, managers and governing boards. They have not had to recognize this liability because the bill was not yet due. For many utilities, board/council/commission relationships and customer relationships have developed in recent decades in the absence of a recognized need for significant investment in replacing the utility's assets as they age and wear out.

Pipes are hearty, but ultimately mortal.

The oldest cast iron pipes—dating to the late1800s—have an average useful life of about 120 years. This means that, as a group, these pipes will last anywhere from 90 to 150 years before they need to be replaced, but on average they need to be replaced after they have been in the ground about 120 years. Because manufacturing techniques and materials changed, the roaring '20s vintage of cast-iron pipes has an average life of about 100 years. And because techniques and materials continued to evolve, pipes laid down in the Post-World War II boom have an average life of 75 years, more or less. Using these average life estimates and counting the years since the original installations shows that these water utilities will face significant needs for pipe replacement over the next few decades.

The modern public water supply industry has come into being over the course of the last century. From the period known as the "Great Sanitary Awakening," that eliminated waterborne epidemics of diseases such as cholera and typhoid fever at the turn of the last century, we have built elaborate utility enterprises consisting of vast pipe networks and amazing high-tech treatment systems. Virtually all of this progress has been financed through local revenues. But in all this time, there has seldom been a need to provide for more than modest amounts of pipe replacement, because the pipes last so very long. We have been on an extended honeymoon made possible by the long life of the pipes and the fact that our water systems are relatively young. Now that honeymoon is over. From now on and forevermore, utilities will face significant requirements for pipe repair, rehabilitation, and replacement. Replacement of pipes installed from the late1800s to the 1950s is now hard upon us, and replacement of pipes installed in the latter half of the 20th Century will dominate the remainder of the 21st.

We believe that we stand today at the dawn of a new era—the replacement era—for water utilities. Over the next three decades, utilities will be in an adjustment period during which they will incorporate the costs of pipe replacement in routine utility spending. This will require significant adjustments in utility revenues. The magnitude of the need and the invisibility of that need to the person on (top of) the street will make this a particularly challenging adjustment. The need for significantly greater investment in pipe replacement is all the more difficult to convey because it was never there before. It's hard to explain why it's going to cost more to do the same job in the future than it cost in the past.

Many water systems all across America have seen this day coming and have already begun to ramp up their expenditures on pipe rehabilitation and replacement. But for many utilities this problem is just emerging and is enormous in scope. For them the water supply business will never be the same.

Back to the future: pipe replacement needs are a "demographic echo."

To understand the nature and scope of the emerging infrastructure challenge, AWWA undertook an analysis of 20 utilities throughout the nation. The analysis projects future investment needs for pipe replacement in the 20 utilities and provides a forecast called a "Nessie Curve." The Nessie Curve is a graph of the annual replacement needs in a particular utility, based on when pipes were installed and how long they are expected to last in that utility before it becomes economically efficient to replace them. There are, of course, a number of factors that can require the replacement investment to be made earlier. In many cities, for example, there are urban redevelopment efforts or similar major construction projects that could require up-sizing or other modernization of the pipe network before the pipes reach the end of their useful lives.

Data on repair and replacement needs for each of the 20 cities in our sample is presented in Appendix A. This information is presented for each city as a "Nessie Curve," that is, a projection of the city's economically efficient investment in pipe repair and replacement, based on the city's original pipe installation profile and how long the pipes last in that utility. The aggregate Nessie Curve for all 20 utilities is presented in Figure 3. The rising wave shape suggests why the curve is named after the Loch Ness Monster.

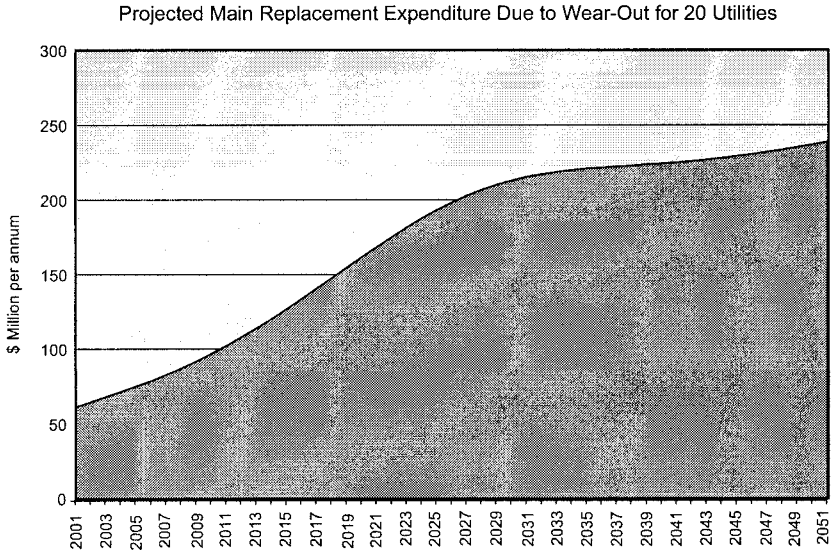


Figure 3

The Nessie Curve reflects an "echo" of the original demographics that shaped a particular utility. It is very similar to the echo of demographics that predicts future liabilities for the Social Security Trust Fund. Indeed, this is exactly the same type of problem that faces Social Security. Historical demographic trends—in our case, pipes laid down as long as a century ago—created a future financial obligation that is now coming due. By modeling the demographic pattern and knowing the life expectancy of the pipes, we can estimate the timing and magnitude of that obligation.

Just as in Social Security, a threat to affordability arises when there were powerful demographic and economic trends at work originally, but the liability arrives at a later time when the demographic and economic conditions have changed. In the water business, the challenge is magnified by pipes that last through several generations of customers before they need to be replaced.

Reflecting the pattern of population growth in large cities over the last 120 years, the Nessie Curves in Appendix A forecast investment needs that will rise steadily like a ramp, extending throughout the 21st Century. The curves show that replacement expenditures will have to rise steadily for the next 30 years. By 2030, the utilities in our sample of 20 will have to spend on average over three-and-a-half times as much per year as they do now (in constant dollars) to replace pipes that have reached the end of their economic lives. Some of the utilities in our sample will encounter the steepest part of the incline in the first 10 years. Others will encounter most of the rise over 20 years, while some will experience a sustained increase over 30 years.

Of course, every city has a different demographic history. In addition, numerous local factors will affect the life of a utility's pipes and therefore its Nessie Curve. Each utility has a unique set of circumstances and therefore a different set of infrastructure funding challenges in the future. Nonetheless, demographics will produce the same type of lagged replacement schedule in any major city.

If that were not enough of a challenge, there is an important corollary. As pipe assets age, they tend to break more frequently. But it is not cost-effective to replace most pipes before, or even after, the first break. Like the old family car, it is cost-efficient for utilities to endure some number of breaks before funding complete replacement of their pipes.

Considering the huge wave of aging pipe infrastructure created in the last century, we can expect to see significant increases in break rates and therefore repair costs over the coming decades. This will occur even when utilities are making efficient levels of investment in replacement that may be several times today's levels. In the utilities studied by AWWA, there will be a three-fold increase in repair costs by the year 2030 despite a concurrent increase of three and a half times in annual investments to replace pipes.

It is important to note that a Nessie Curve is a prediction, not a destiny. That is, a utility can choose to manage its infrastructure replacement needs in various ways. For example, the utility may accept increased break repair costs up to a point and delay the replacement of an old pipe, rehabilitate certain pipes to "buy time," or adopt other asset management techniques to extend the life of the pipes as long as possible. Nevertheless, it appears inevitable that many utilities will face substantial increases in infrastructure investments over the next 30 years, to replace pipes laid down as long as 120 years ago.

A final observation from our sample of 20 Nessie Curves is that the large "demographic wave" of replacement needs is only just now upon us. We are just now at the time when there is a compelling need to significantly increase the levels of replacement spending in most utilities. Importantly, there is no evidence that utilities are "behind the curve" or that America is in ruins. That is not the nature of the challenge. We are not faced with making up for a historical gap in the level of replacement funding. In fact, break rates in our sample of 20 utilities are within a range that is considered representative of best management practices for water utilities, indicating that the utilities have made efficient decisions and managed well up to this point. The challenge is ramping up utility budgets to prevent a "replacement gap" from developing in the near future. Unfortunately, keeping up with replacement needs is about to get a lot harder than ever before, and it's going to stay that way. We are coming face-to-face with a serious challenge that could become a crisis if we ignore it.

Water infrastructure is local and therefore vulnerable to demographic changes.

Water utilities are the last natural monopolies. The large investment required in pipe networks makes it impossible to have more than a single provider of water service within a given area. These large investments are also a major source of financial vulnerability for water utilities as the result of the very fixed nature of the assets and the very mobile nature of the customers. When populations grow, the infrastructure is expanded, but when people move away, the pipe assets and the liability for repair and replacement remain behind, creating a financial burden on the remaining customers.

Figure 4 is a plot of U.S. Census population data for Philadelphia from 1850 to 1996. Over the 100 years from 1850 to 1950, the population grew from 100,000 to 2 million people. But from 1950 to the end of the century, Philadelphia lost 25 percent of its population, dropping to 1.5 million. This picture tells a story that was replicated again and again

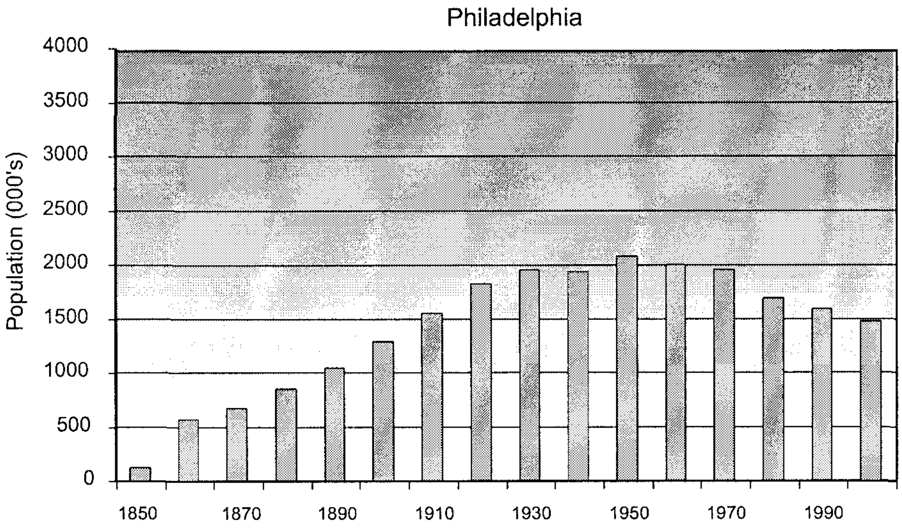


Figure 4

throughout the Rustbelt cities of the Northeast and Midwest. The effect is to significantly increase the burden of replacement funding on the remaining residents of the city.

As previously discussed, the average per-capita value of water main assets in place today across our sample of 20 utilities is estimated to be three times the amount that was present in 1930. In Philadelphia, however, that ratio is almost eight times the value in 1930 due to population declines since about 1950. This problem, known as "stranded capacity" (essentially, capital facilities that are not matched by rate revenue from current customers), is typical of Rustbelt demographics and adds considerably to the challenge of funding replacement in these cities.

Urban demographic history also explains many other dimensions of the infrastructure replacement challenge facing the water industry. Both gains and losses in urban populations created small system infrastructure problems in their wake. During the first half of the 20th Century, many of the people swelling the populations of the urban centers came from smaller rural towns, leaving small water system infrastructure behind to struggle with fewer customers. In the latter half of the century, the departure of big city residents for the suburbs fueled an explosion of new, small water systems in suburban areas. Today about half of all small water systems are within Standard Metropolitan Statistical Areas defined by the U.S. Census. Built in boom times, many of these suburban systems were not built to enduring standards, creating another liability. When these systems are absorbed by larger metropolitan systems, it is commonly necessary to completely rebuild them.

The pattern reflected in Sunbelt cities is the other side of the story from that in the Rustbelt. These cities are experiencing rapid growth and expansion which places capital financing demands upon them that are truly the opposite side of the coin. When water utilities are expanding, they must build some of the most expensive components—new source development, storage facilities, transmission mains, and treatment plants—in advance of population growth in order to serve people when they arrive. This is, in effect, another form of stranded capacity—capital facilities that must be paid for despite the fact the customers are not yet in place. Investor-owned utilities are, in fact, generally prohibited by state regulatory commissions from recovering such costs in rates.

Demographic change thus places financial strain on all our public water systems. It is the same whether they are large or small; urban or rural or suburban; and Rustbelt or Sunbelt. The inescapable fact is that water infrastructure is fixed while populations are mobile. The result is a form of "market failure"—an adverse side effect of market activity that creates an unfunded liability. America derives tremendous economic strength from the fact that it has a highly mobile labor force. When people move around, however, there are costs imposed on the local water infrastructure. It is the same whether it is people moving from rural towns to the city, from the city to the suburbs, or from the Rustbelt to the Sunbelt. Our labor mobility imposes a significant cost on water utilities on both the giving end and the receiving end of this market process, while the benefits are generally disseminated throughout the national economy.

Replacement of water treatment plants is also coming due.

Replacement of water treatment assets presents a different picture from that of the pipes, but greatly complicates infrastructure funding for utilities. Major investments in water and wastewater treatment plants were made in several waves following the growing understanding of public health and sanitary engineering that evolved during the 20th Century. Of course, the installation pattern of treatment assets also reflects major population growth trends. But whereas pipes can be expanded incrementally to serve growth, treatment must be built in larger blocks. Investments in treatment thus present a more concentrated financing demand than investments in pipes.

Treatment assets are also much more short-lived than pipes. Concrete structures within a treatment plant may be the longest lasting elements in the plant, and may be good for 50 to 70 years. However, most of the treatment components themselves typically need to be replaced after 25 to 40 years or less. Replacement of treatment assets is therefore within the historical experience of today's utility managers. Even so, many treatment plants built or overhauled to meet EPA standards over the last 25 years are too young to have been through a replacement cycle. Many are about due for their first replacement in the next decade or so.

The concurrent need to finance replacement of pipes and of treatment plants greatly increases the challenge facing utilities. Figure 5 presents a Nessie Curve showing both pipe replacement and treatment replacement needs for the Bridgeport Hydraulic Company. Similar Nessie curves for a number of other utilities are included in Appendix A.

The distinguishing characteristic of this graph is the manner in which spending for the replacement of pipes rises like a ramp over the first part of the century, pushing up the overall level of annual expenditure required. Whereas pipe repair and replacement are generally funded out of current revenues, treatment costs are typically debt-financed. As

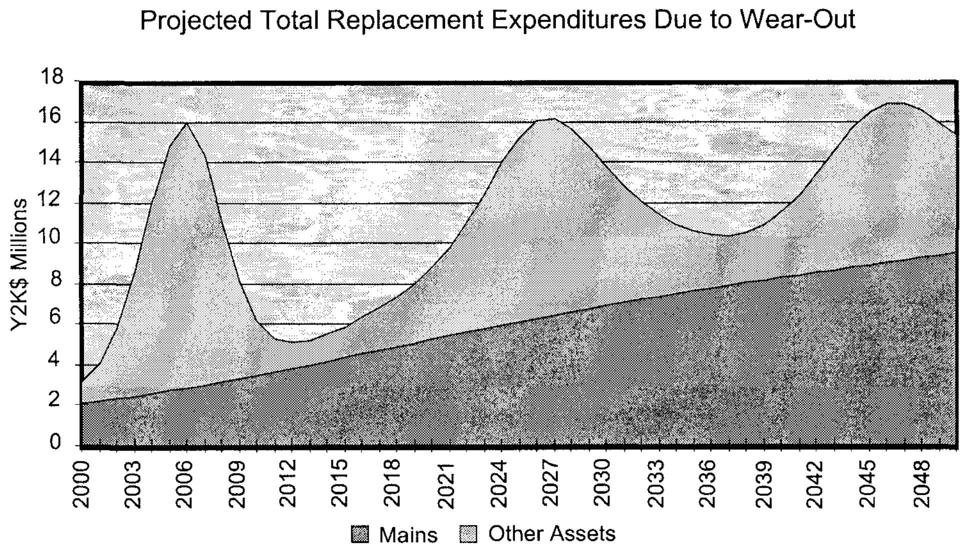


Figure 5

utilities face ever rising costs for repair and replacement of pipes, more and more of the utility's rate revenue will be required for those investments. This will leave the utility with increasingly weakened credit every time it gets to another "treatment hump," unless rates can be raised to match the slope of the curve. A final point to note about the treatment cost estimates used in developing Figure 5 and others like it in Appendix A is that these do not include the cost of new drinking water regulations likely to be implemented over the coming decades.

Increased expenditures are needed to climb the ramp and avoid a gap.

The Water Infrastructure Network (WIN) has developed a "gap analysis" to estimate the total increased spending that is required by water and wastewater utilities in order to avoid getting behind in funding infrastructure replacement over the next 20 years.[1] The first step in the WIN estimate is accomplished by extrapolating from Census data on historical utility expenditures for 20 years into the future. The resulting baseline expenditure forecast is then examined to see how much it must be increased in order to meet new expenditure "needs" for both new EPA compliance requirements and infrastructure repair and replacement over the same 20-year period. The "gap" between the baseline expenditure forecast and the future "needs" forecast is the amount of additional expenditure that must be forthcoming in order for water and wastewater utilities to maintain their critical infrastructure in a healthy condition.

The findings of this "gap analysis" indicate that the baseline expenditures of water utilities must be increased by about $300 billion over 20 years to keep up with both compliance and infrastructure needs. In similar fashion, the baseline expenditure trend in wastewater utilities must be increased by about $400 billion to meet such needs. Taken together, and accounting for the cost of capital, WIN has estimated that water and wastewater utilities together need to increase their investments in infrastructure by almost $1 trillion over the next 20 years.

The WIN "gap analysis" is easily misunderstood. Many have interpreted it to mean that a trillion-dollar deficiency already exists. It is important to stress that the gap estimate represents the challenge ahead—the ramp that we must climb—in increasing utility expenditures in order to avoid such a deficiency. The AWWA Nessie Curve analysis of 20 utilities indicates that we are not now behind in maintaining our water infrastructure. There is no current crisis in these 20 utilities. Rather, they are challenged with finding significant additional funds over the next 30 years for investments in repair and replacement, in order to avoid getting behind.

Extrapolation from aggregate baseline trends, such as in the WIN gap analysis, is akin to "technical analysis" of the stock market using charts, graphs and trending techniques. Investment analysts typically like to supplement such "technical analysis" with "fundamental analysis" of the situation existing within individual companies. The AWWA Nessie Curve analysis provides this type of supplemental perspective on increased expenditure needs.

[1]Water Infrastructure Network (WIN), Clean & Safe Water for the 21st Century, April 2000.

As illustrated in Figure 5, the Nessie Curve analysis indicates that expenditures on infrastructure repair and replacement must be significantly ramped-up over a period extending from 2000 through 2030. The steep rise is shown to level off after that, but it does not go away. Expenditures will have to continue to climb, albeit more gradually, throughout most of the rest of the 21st Century. This shape is the signature pattern of the new replacement era that we have entered. It is not a short-term "hump" that we have to get over. The shape of the challenge is that of a sustained rise in expenditures. This period of ramping-up is going to be a period of significant adjustments.

The Nessie Curves of the individual utilities shown in Appendix A present wide-ranging needs for increased expenditure for replacement of pipes and treatment assets due to wear-out. In the 20 utilities studied, such needs total about $6 billion above current spending over the next three decades. On a household basis, needs range from $550 to $2,300 over 30 years. These figures do not include the prospective costs of numerous new SDWA regulations likely to be implemented over the coming decade, nor any costs from the wastewater or stormwater side of the urban utility business. Moreover, as seen in Appendix A, the utilities vary widely in the timing of these needs; some face sharp needs in the next 10 years, while others don't face their highest needs for 10 or 20 years. The slope and the "humpy" patterns of increasing capital requirements are unique to each utility.

Our sample of 20 utilities represents relatively large water utilities. On a per household basis, the total 20-year capital needs for replacement illustrated in our sample is about the same as that estimated by EPA for large water systems in their newly released Drinking Water Needs Survey.[2]

The EPA Drinking Water Needs Survey uses a site visit methodology and a large sampling program to document needs in small systems and is probably the best information available on small system needs. Extrapolating from EPA's estimated 20-year capital need for small systems, we project the total 30-year expenditure for infrastructure repair and replacement in small systems might be in a range of $1,490 per household to $6,200 per household.

The result of this "fundamental analysis" using Nessie Curves is not inconsistent with the order of magnitude of the need that WIN estimates to be facing water utilities ($300 billion over 20 years). Extrapolation from our 20 sets of Nessie Curves suggests that the need might be on the order of $250 billion nationally and extend over three decades. However, the Nessie Curve forecast is based on an assumption that pipes are left in the ground until their economic life is over. The reality in utility operation is that myriad other influences can cause the replacement need to arise sooner. These include urban redevelopment, modernization, coordination with other city construction schedules, increasing pipe size, and other factors.

[2] U.S. Environmental Protection Agency, 1999 Drinking Water Infrastructure Needs Survey (EPA 816-R-01-004), February 2001.

Addressing affordability is the heart of the challenge.

The central question for policy makers and utilities is whether the increased rate of infrastructure spending that utilities must face over the next 30 years can be financed by the utilities themselves at rates customers can afford. AWWA remains, committed to the principle that utilities should be self-sustaining through their rates. For many utilities, however, the degree of change involved in adapting to the dawning replacement era, the adverse effect of demographic change on per household costs, and the competing demand for investment in wastewater and other municipal services, will combine to present a significant affordability challenge.

There are two related dimensions to the affordability concern. First is the ability of utilities to finance the needed additional expenditures within their rates. Second is the impact of higher rates on households.

In developing this study, AWWA brought together a group of utility managers from across the country to discuss infrastructure issues. This group characterized the question from a local perspective as an "affordability gap" or a "reality gap" and defined it as "the difference between what you think you should be spending on infrastructure and what you or your customers can afford to spend in reality." This characterization of the problem reflects the difficulty of obtaining significant utility rate increases. Rate increases are best received when implemented gradually in a number of installments over several years. Unfortunately, the rate increases required to meet the challenges of pipe replacement that utilities now face cannot be smoothly implemented in many cases.

There is small likelihood that the $550 to $2,300 per household projected to be required for infrastructure repair and replacement in our 20 utilities over the next 30 years can be spread evenly or taken on gradually over that period. As illustrated in Appendix A, some Nessie curves present a steeper funding challenge and some present a gentler slope due to local variations in the historical demographic trends. There are "humps" on the up-ramp for replacement of treatment plants and other equipment. Additional "humpy" expenditures for compliance with anticipated new regulations are not included. In small systems, the estimated $1,490 to $6,200 range of household impact is likely to be even more concentrated since the original demographics were themselves more concentrated.

Compliance-driven requirements to replace treatment plants and invest to meet new mandates will also dominate expenditures and push aside the more subtle need for investments in pipe replacement. This is exacerbated by the fact that the costs of water and wastewater service appear on the same bill in most communities. Thus, the needs to replace wastewater treatment plants and to replace wastewater lines compete with drinking water needs for the same consumer dollar. Sewer pipes generally impose higher unit replacement costs than water pipes, owing to their inherent characteristics (size, depth, etc.). Figure 6 presents a Nessie curve for a combined water and wastewater utility showing replacement funding needs for both water and wastewater pipes and other assets (treatment, pumping, etc.). The figure illustrates the typical relationship between water supply and wastewater costs—wastewater facilities cost noticeably more to replace.

The combined repair and replacement needs for water and wastewater infrastructure amount to a significant financing challenge in their own right. But the cost of compliance

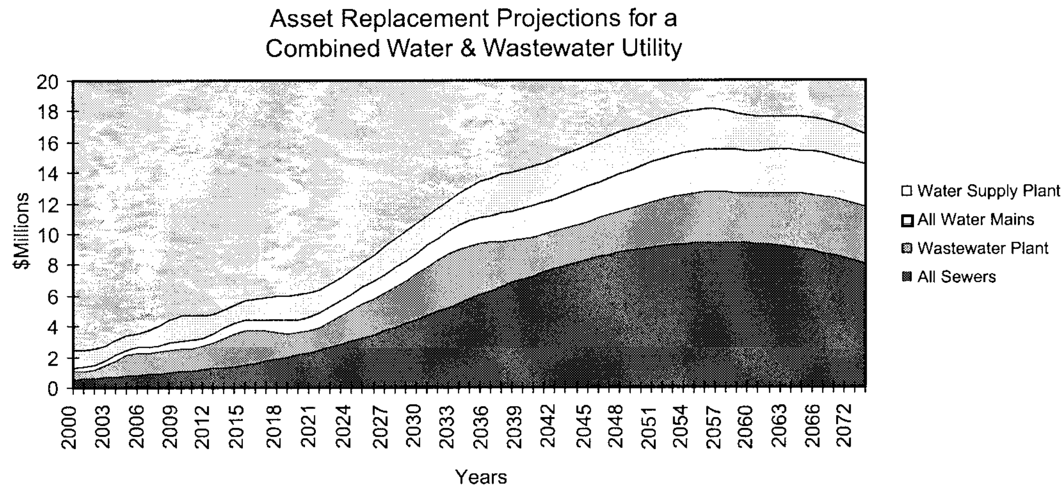


Figure 6

with combined sewer overflow (CSO) and stormwater regulations may dwarf everything else in water and wastewater utilities. The scale of the expenditure required in these programs may sweep everything else aside in some utilities, causing deferral of other needs and allowing a "gap" to open up. Note that CSO and stormwater compliance costs are not included in Figure 6.

To avoid an infrastructure gap, utilities are going to have to increase expenditures to keep up with both compliance requirements and infrastructure replacement. If rate increases do not keep pace with the increased rate of expenditures, the financial ratios used to evaluate a utility's creditworthiness will deteriorate, making it more difficult and more expensive to raise capital.

If a utility attempts to balance a deficiency in allowable rates by deferring infrastructure expenditures, then the stage is set for an infrastructure investment gap to begin to develop, creating a future liability for the utility and its customers. With the new accounting requirements being implemented under the Governmental Accounting Standards Board Statement No. 34 (GASB 34), such a deferral of infrastructure expenditures will be reported to the financial markets and begin to impair the utility's credit rating and ability to raise capital.

Since the Nessie Curve represents replacement timing based on the economic life of the pipes, it follows that deferral of replacement will produce higher overall costs due to increased repairs than would be the case if replacement occurred on time. If replacement is deferred too far beyond the economic trade-off point between replacement and repair costs, the repair cost burden will spiral upwards and have significant impacts on utility cash flows. Such a scenario will indeed impair a utility's ability to repay debt and will be made plain to the credit markets by the new GASB 34 requirements.

In either of these scenarios—rates that don't keep up with expenditures or expenditures that don't keep up with needs—the bottom line is the same. If both expenditures and rate revenues cannot be increased at the required rate, then the utility's credit may be impaired, and it may face even higher costs as a result. For some utilities, there is the potential for this to become a vicious cycle—a financial trap. These systemic financial risks are the reason why we have a clear and present need for an enhanced partnership between utilities, states and the federal government. We need to provide the means to assist utilities "up the ramp and over the humps." We need to minimize the credit risks utilities face over the next three decades as we make the adjustments in rates required to assure sustainability in the new replacement era.

The second, and all important, dimension of the affordability challenge is the bottom-line impact of increased water rates on household budgets. AWWA believes it is critical to avoid sudden and significant changes in rates that can induce "rate shock" among customers. The broader issue involved in rate shock ties back to the pivotal role of safe drinking water in promoting public health.

America has by far the safest drinking water in the world. Standards promulgated under the Safe Drinking Water Act aspire to the highest levels of technology and treatment optimization known to science. As we push farther into the limits of science and technology, we unavoidably encounter diminishing returns in terms of quantifiable health benefits at the same time that we must take on increasing marginal costs. Many new standards relate to very subtle health concerns that are difficult to substantiate and quantify. Yet, to be protective of health, there is a tendency to err on the side of safety, especially when the threats may relate to sensitive subpopulations such as children, the unborn, the elderly and the health-impaired.

This is where the issue of rate shock must be brought into focus as a public health concern. Whenever the sensitive subpopulations we are striving to protect are also among the low-income segment of the population and are forced to forego medical care or nutrition in order to pay their utility bills, we could be doing more harm than good. The fact that we are now entering a significantly more expensive replacement era in water infrastructure makes it all the more difficult to maintain the right balance in this aspect of public health. By some comparisons, it may appear that water is still cheap and there is room to increase water rates. But such comparisons are not relevant to low-income households. The only comparison that matters in these households is the size of the incremental increase. If it is large enough to trigger a budget substitution that negatively affects family health—for example, giving up a prenatal visit in order to pay a utility bill—then we may be losing ground.

Over the past decade, utilities have formed an increasingly closer partnership with EPA, states, the environmental community, the public health community and other groups to continue to make progress for public health despite significant scientific challenges. This partnership must now be broadened to address the financial challenges of infrastructure replacement in order to preserve the fruits of our labors in the public health arena.

Considering all of these facts, the American Water Works Association believes it is time for a new American partnership for clean and safe water. This partnership requires that all levels of government and utilities play a role in working through the significant challenges ahead. Specifically, we recommend:

1) Measures by Utilities and Local Governments

The infrastructure funding issue varies from place to place, reflecting the age, character and history of the community. Although AWWA has looked at the infrastructure issue in the aggregate, many key questions must be asked and answered at the local utility level. The development of a comprehensive local strategy can bring these elements into focus and create a new "reality" that will help make infrastructure repair and replacement more affordable. Such a comprehensive strategy includes:

- **Assessing the condition of the drinking water system infrastructure.** Over the last few decades, utilities around the world have been developing innovative new approaches to managing long-lived buried infrastructure. In North America and overseas, some utilities are already taking advantage of tools such as geographic information systems, using new information to advance the state of the art and aggressively managing infrastructure replacement. Planning tools can help identify and plan for needed investment decades in advance of the actual need for funds. We should learn from, adapt, and use such tools.
- **Strengthening research and development.** Although there is not likely to be a single "silver bullet" to solve infrastructure management problems, an impressive array of technological tools have been moving through the research and development process in recent years. Efforts to develop and deliver such tools should be strengthened.
- **Working with the public to increase awareness of the challenge ahead, assess local rate structures, and adjust rates as necessary.** For many years, water and wastewater utilities have been nicknamed "the silent service." Utilities have quietly provided an extremely reliable supply of high-quality water at relatively low rates compared to other public utilities and services. Partly as a result, a large number of utilities, particularly smaller ones, do not have appropriate rate structures. The 1996 SDWA requirement for Consumer Confidence Reports provides a vehicle for many utilities to take the first step in broadening their dialogue with customers and the public at-large. Comprehensive, focused, and strategic communications programs serve the dual function of providing consumers with important information about their water systems and building support for needed investments in infrastructure.
- **Building the managerial capacity of many water systems.** Congress took new steps in the 1996 SDWA Amendments to assure the institutional capacity of small systems applying for state revolving fund loans. Much more remains to be done in this area. EPA, in conjunction with water associations, could sponsor training programs on appropriate rate structures, designed specifically to deliver assistance to small systems in planning for full cost recovery through rates.

2) Reform of State Programs

The states, too, have an important role to play in addressing our infrastructure funding needs. States may need to match an appropriate share of any new federal funds that are provided for infrastructure assistance. Moreover, they need to reform their existing programs to make them more effective. For example, some states have not allowed larger systems to access the existing state revolving fund, or have excluded investor-owned systems. Some states encumber their revolving funds with nonproductive red tape, charge high loan origination and other fees, or charge loan rates that are equivalent to market rates. Some states preclude the use of alternate procurement methods that minimize infrastructure procurement costs. For example, the "design/build" process for infrustructure procurement has been documented to save 20–40% of construction costs for new treatment plants in some cases. Public procurement laws in many states, while not explicitly banning design/build, mandate a process that prevents its use where local authorities have determined it would be advantageous.

The result is that, in many states, revolving loan funds have not proved to be useful or attractive even to drinking water utilities desperately in need of capital. States should commit to:

- Respecting the universal eligibility of all water systems for federal assistance.
- Streamlining their programs for delivery of assistance and allowing alternative procurement procedures that save money.
- Making their financing mechanisms more attractive by committing to grants and very low or negative interest loans.
- Using federal funds in a timely fashion or facing the reprogramming of those funds to other states.

3) A Significant Increase in Federal Assistance

After accounting for the cost savings that can come from best practices in asset management, the development of new technologies, efforts to increase ratepayer awareness and support, and possible alternative compliance scenarios, for many utilities there is likely to remain a gap between the required expenditure increases and the practical ability to raise water rates. This gap could grow over the next few decades as infrastructure built in the late-1800s to mid-1900s must be repaired, replaced, and rehabilitated at the same time that we are trying to enhance the level of water treatment under the Safe Drinking Water Act (SDWA).

AWWA remains committed to the principle that utility operations should be fully supported by rates. In the long run, the objectives must be to manage the costs of replacing pipes and treatment plants and ensure financial sustainability through local rate structures. However, many utilities are going to face a period of adjustment in adapting to the new reality of the replacement era described in this report. Many utilities and their customers will need additional assistance in working through extraordinary replacement needs in the next 20 years.

The difference between drinking water utilities' current expenditures for infrastructure replacement and the needed level of expenditure is estimated by WIN to be about $11 billion per year over the next 20 years. If the federal government were to provide half the cost of this gap, the federal share of total utility spending would amount to under 12 percent of total utility spending. For comparison, the federal share of investment in roads, bridges, and airports is 80 percent.

To prevent the development of a gap in critical water infrastructure financing, AWWA recommends either changing and expanding the existing Drinking Water State Revolving Fund and other drinking water programs or creating a new, infrastructure-focused fund. Such a fund should provide:

- Significantly increased federal funding.
- Clear eligibility of projects to repair, replace, or rehabilitate drinking water infrastructure.
- Universal eligibility of all water systems, both public and investor owned, regardless of size.
- Ability to make grants or loans in any combination and to use other financing tools to leverage public and private capital.
- Reasonable terms and conditions such as demonstration of system viability and ability to repay a loan.
- Streamlined procedures for those accessing the funds.

Research is a critical component of a comprehensive federal program on infrastructure. Research stimulates the development of new techniques and unleashes American ingenuity. It offers the chance to save billions of dollars over the years to come through more efficient management, repair, and replacement technologies. The federal government should significantly increase its support for research on infrastructure management, repair and replacement technologies, methods for extending pipe life, and other means of advancing the art while lowering the cost of infrastructure management.

Finally, the federal government should take other important steps to better access and leverage public and private capital. Congress should consider:

- Development of a national water infrastructure financing bond bank similar to Fannie Mae.
- Tax code and other reforms to increase the availability and use of private capital. This could include steps such as the removal of constraints on private activity bonds, development of subsidized bond insurance, provision of federal loan guarantees, and improved investment tax credit incentives.

CONCLUSION

Considering when pipes were laid down in many water systems and how long they can be expected to last, it is clear that a new age—the replacement era—has arrived for water utilities. Over the next 30 years, infrastructure replacement needs will compete with compliance needs for limited resources. Clearly, infrastructure needs and compliance with the Safe Drinking Water Act can't be approached as separate issues, but need to be addressed together.

Only in the true spirit of a new partnership, as outlined in this report, can we think most broadly about these issues. Only in this spirit can we achieve the goals to which we all aspire: the provision of safe and affordable water to all Americans.

APPENDIX A

20 Sets of Nessie Curves

This appendix presents results of infrastructure expenditure needs analyses conducted for 20 water utilities across the United States. The "Nessie Curve" technique employed in this study produces a forecast of water main and other asset repair and replacement expenditure requirements based on how those assets "wear out" over the course of their economic life. While this study has focused on projecting economically efficient replacement and repair costs from wear-out, there are other reasons why assets might be replaced sooner, such as needs relating to urban redevelopment, system improvements, coordination with other city construction, and increasing pipe size. The curves also focus only on existing assets and take no account of new assets needed to support growth or compliance with new SDWA regulations in the coming decades.

For each utility, results are summarized in several Nessie Curves illustrating different perspectives. For each utility there is an estimate of the total replacement cost value of the utility's assets in today's dollars. There is also an indication of whether the utility was studied with respect to mains only, or whether it was studied with respect to a wider range of assets (including treatment plants). In viewing the charts, it is important to remember whether the utility is an "apple" (mains only) or an "orange" (all assets).

The charts presented cover the next 50 years, primarily to better illustrate the characteristic shapes of the replacement "echo" while also identifying differences in the timing of major replacement requirements between the participating utilities. All values are constant year 2000 dollars. The forecasts assume zero inflation.

The first chart is entitled. "Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)." In this graph, the total cost for replacement and repair due to aging is projected over the next 50 years at the household level.

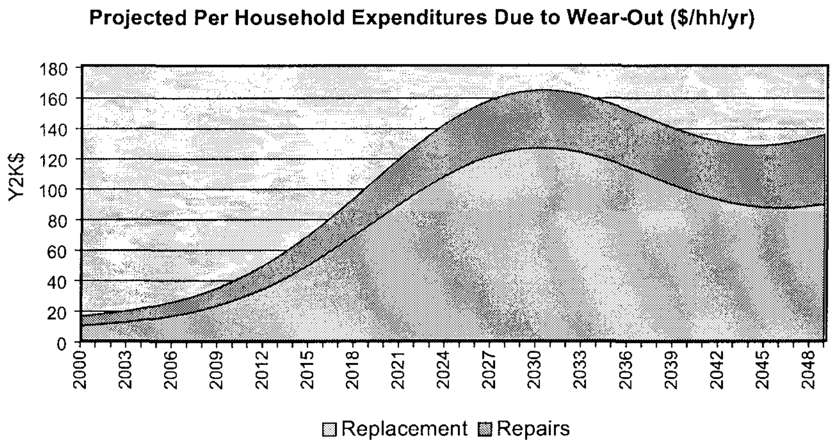
The second chart, entitled "Projected Total Expenditures Due to Wear-Out" is similar to the first chart, showing the relative requirements for replacement expenditures and repair expenditures for the assets studied in each utility, expressed in total dollar outlays for the utility.

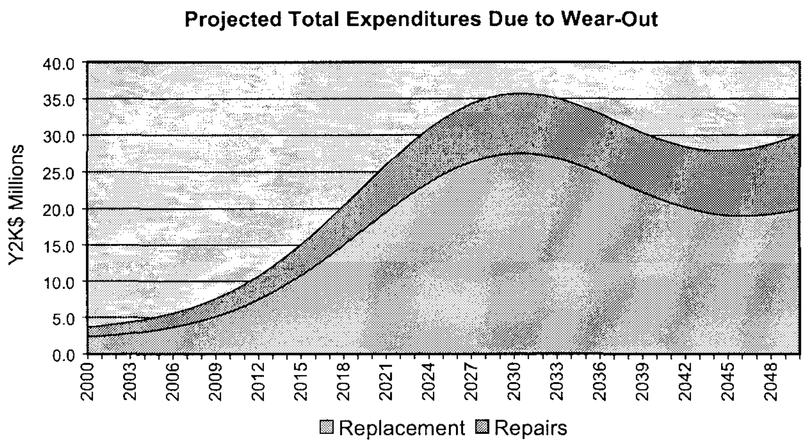
For the utilities that were studied with respect to all assets, there is a third chart on the page entitled, "Projected Total Replacement Expenditures Due to Wear-Out." This chart projects replacement investment only, showing the relative contributions to 50-year replacement needs of mains versus other assets (treatment, pumping, etc.). For utilities that were studied only with respect to mains, this third chart is omitted from the summary page for that utility.

Index of Nessie Curves

Austin, Texas

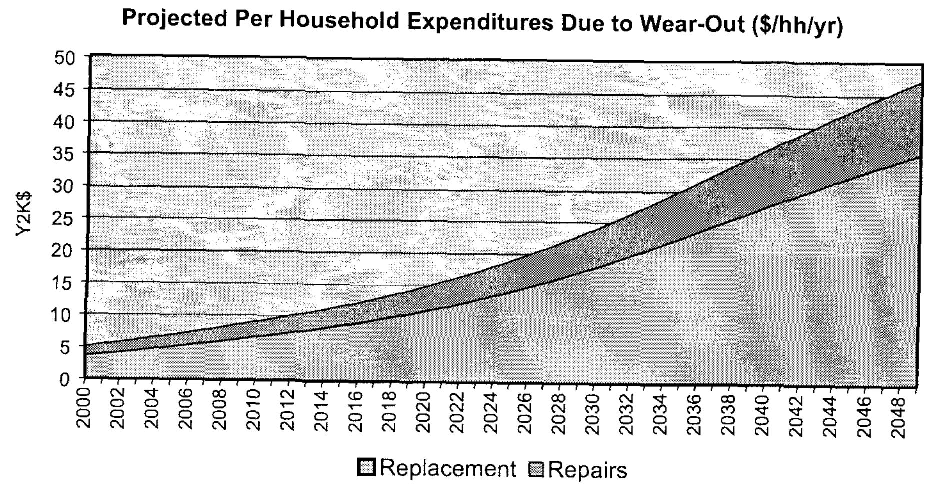
Asset Sets Modeled: Water Mains — Estimated Replacement Value $2,348 M

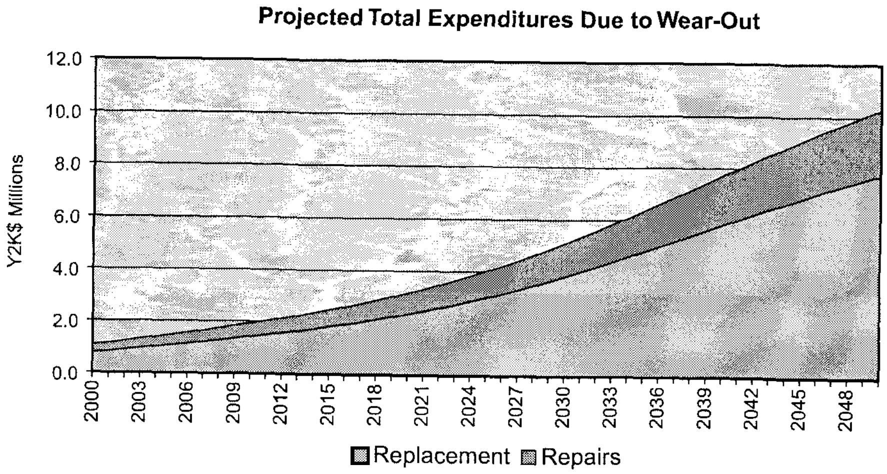




Boston, Massachusetts

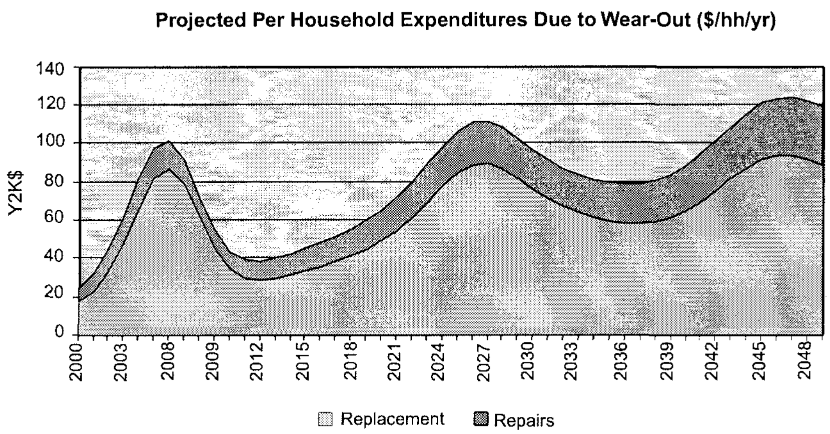
Asset Sets Modeled: Water Mains — Estimated Replacement Value $694 M

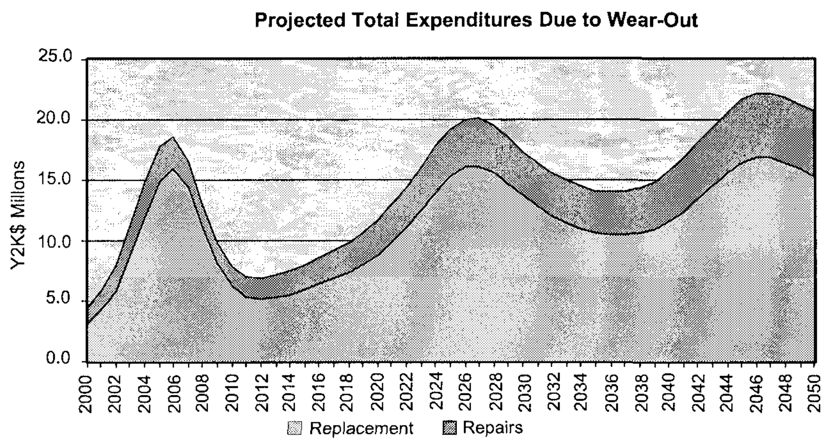


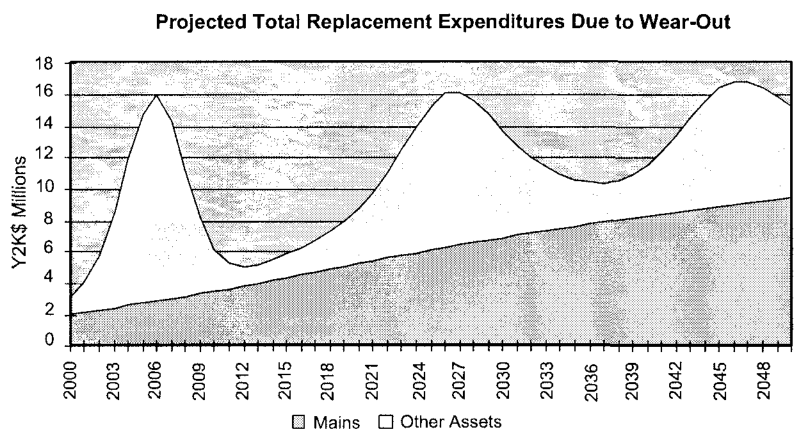


BHC, Bridgeport, Connecticut

Asset Sets Modeled: Water Mains & Water Supply Plant —
Estimated Replacement Value $1,663 M



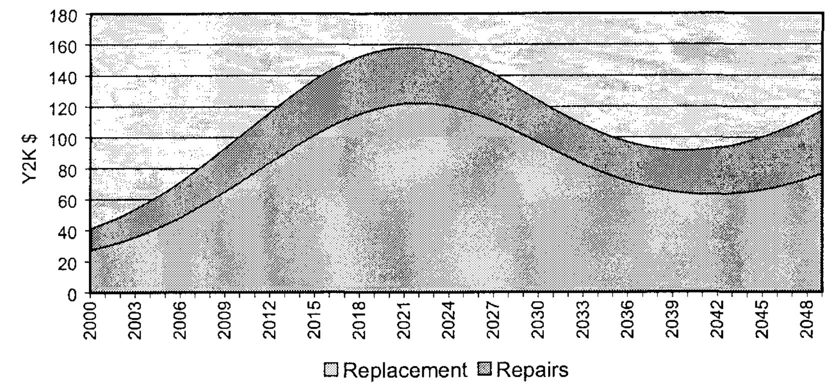




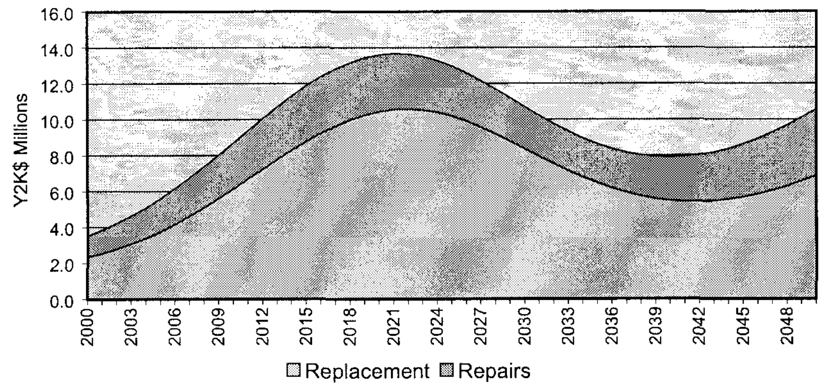
West Virginia American, Charleston, WV

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $650 M

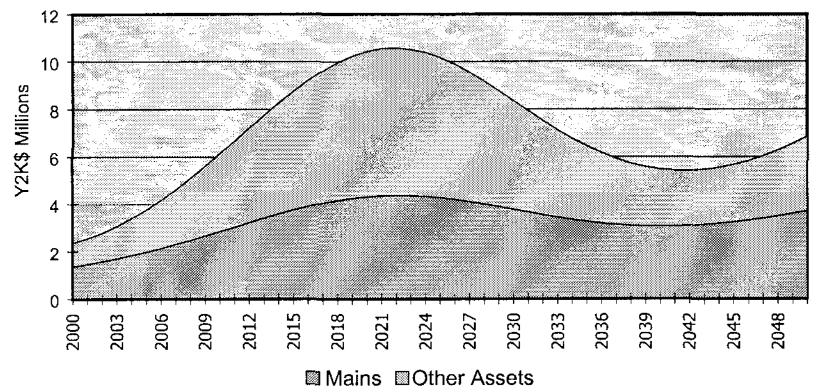
Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)



Projected Total Expenditures Due to Wear-Out

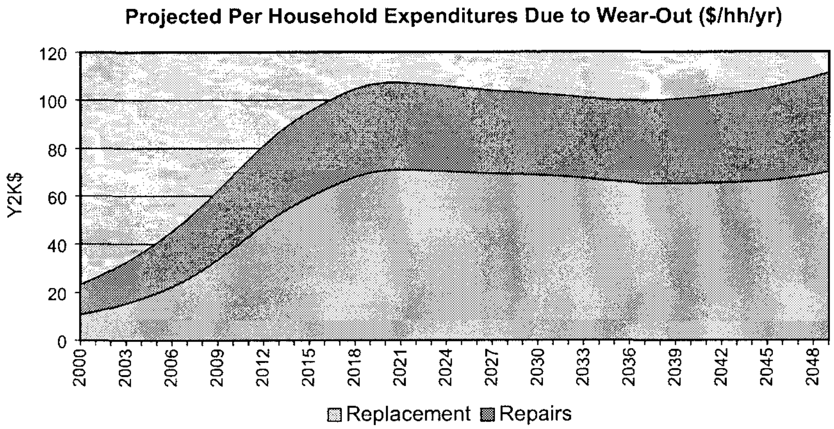


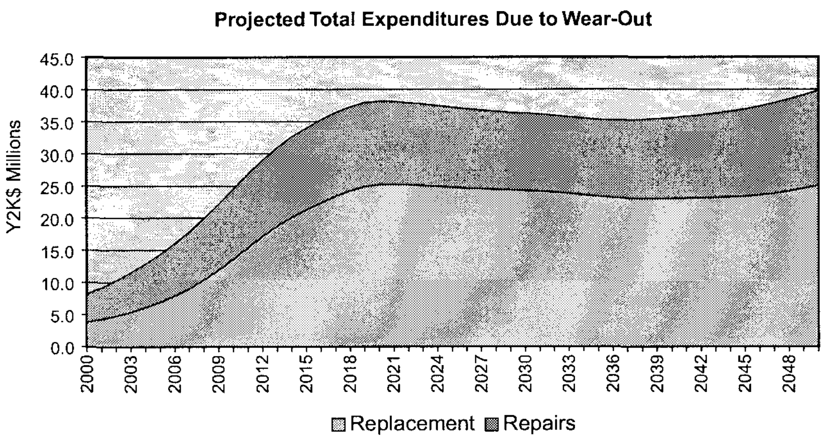
Projected Total Replacement Expenditures Due to Wear-Out

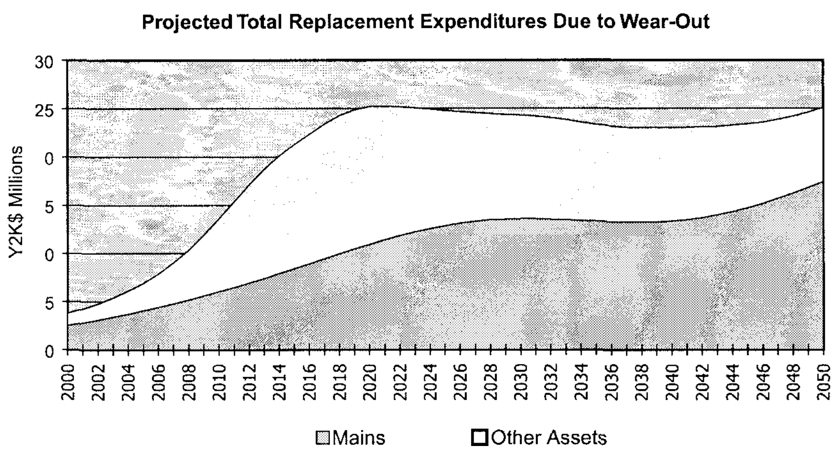


Cincinnati, Ohio

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $2,042 M



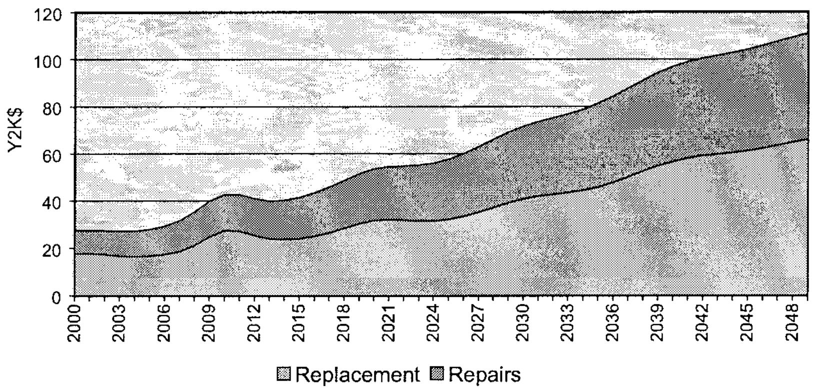




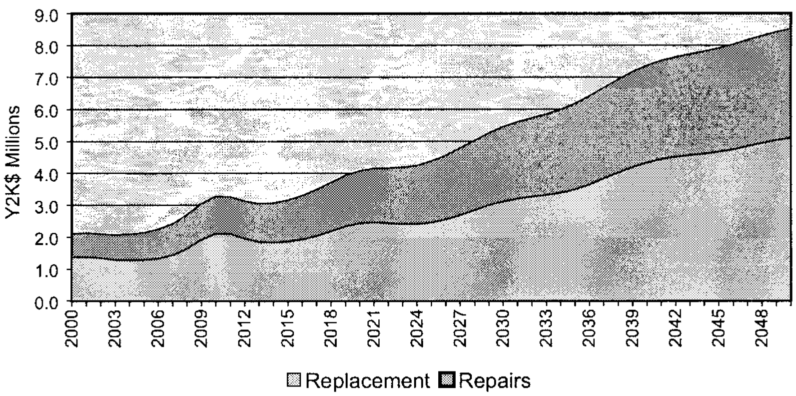
Columbus, Georgia

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $648 M

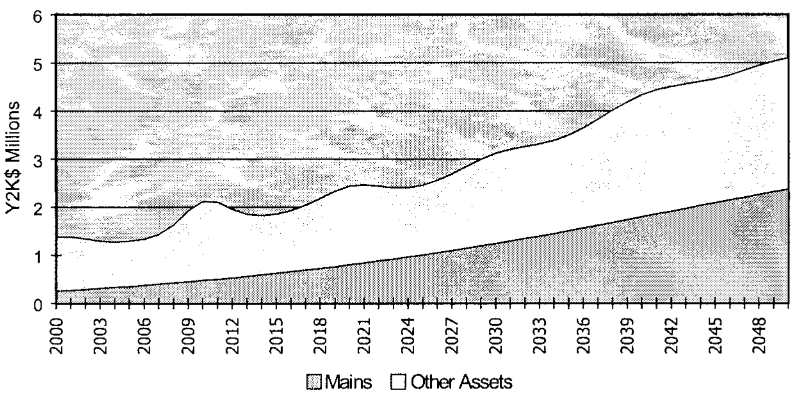
Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)



Projected Total Expenditures Due to Wear-Out

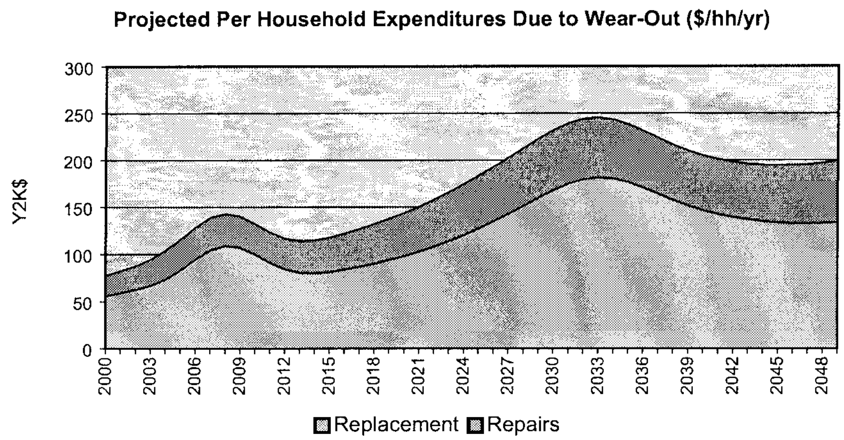


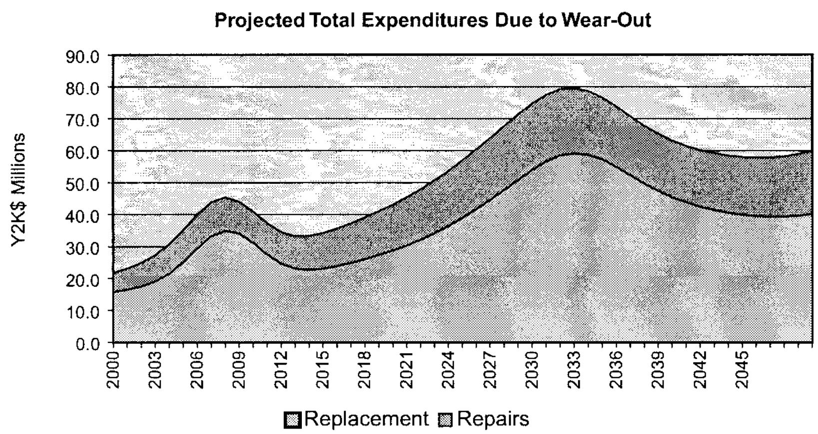
Projected Total Replacement Expenditures Due to Wear-Out

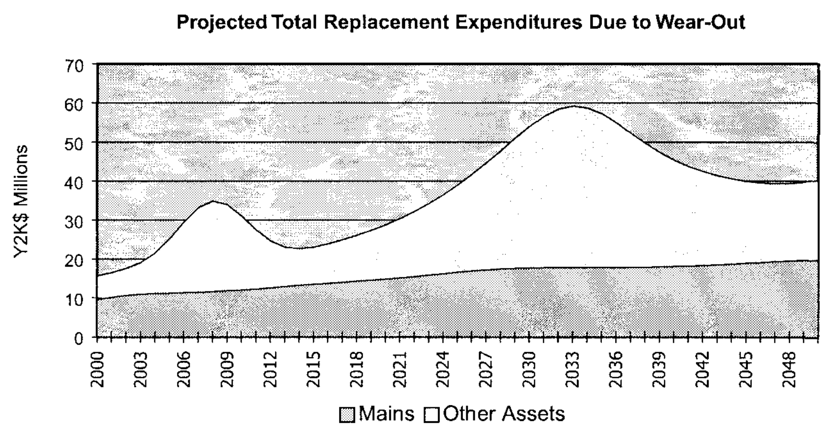


Denver, Colorado

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $5,583 M (Includes Major Dams)



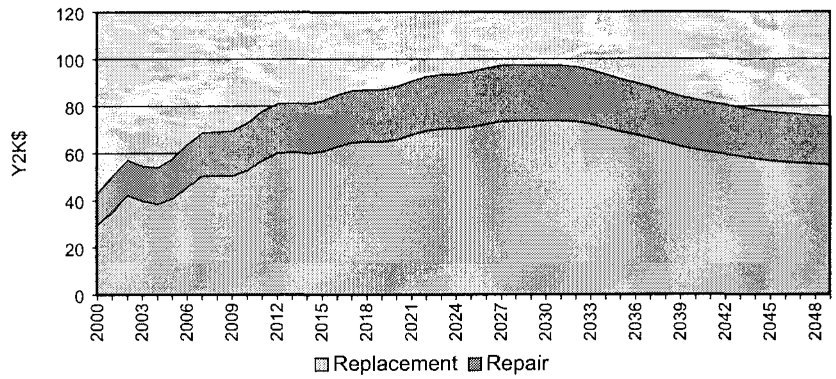




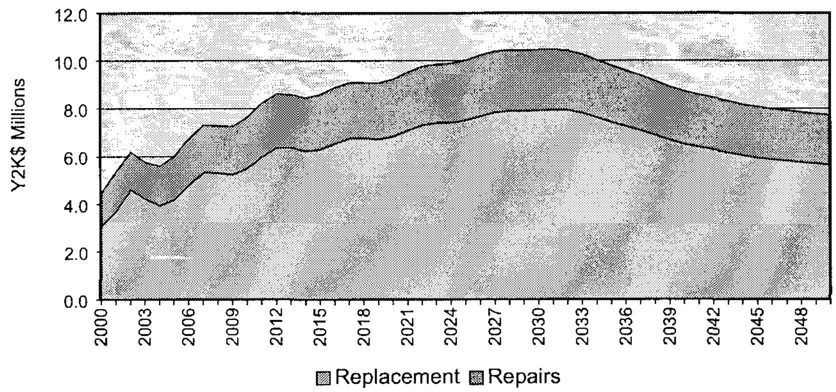
Des Moines, Iowa

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $524 M

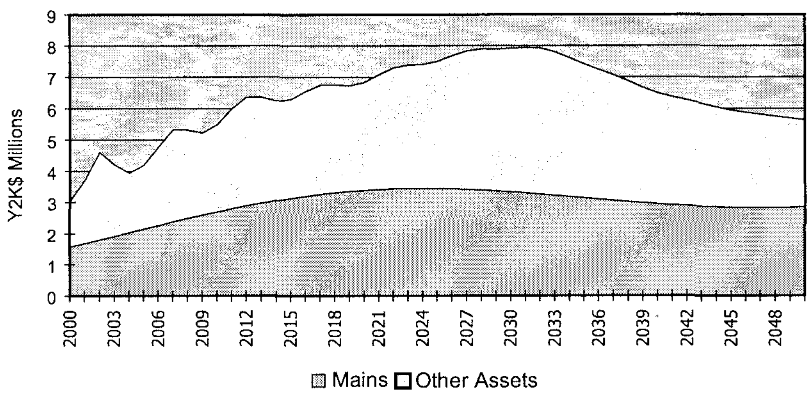
Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)



Projected Total Expenditures Due to Wear-Out



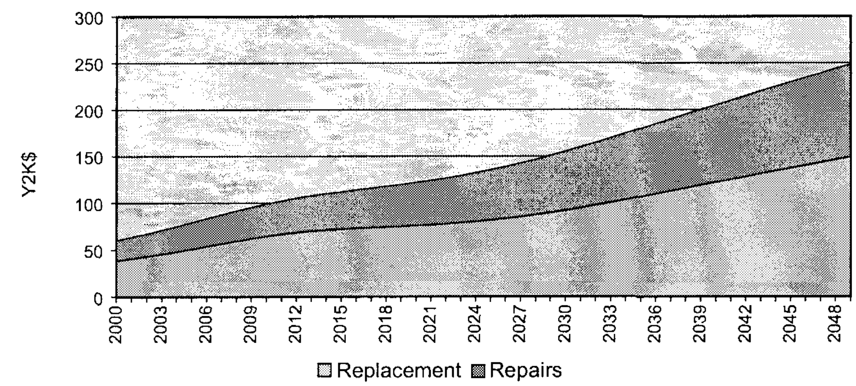
Projected total Replacement Expenditures Due to Wear-Out



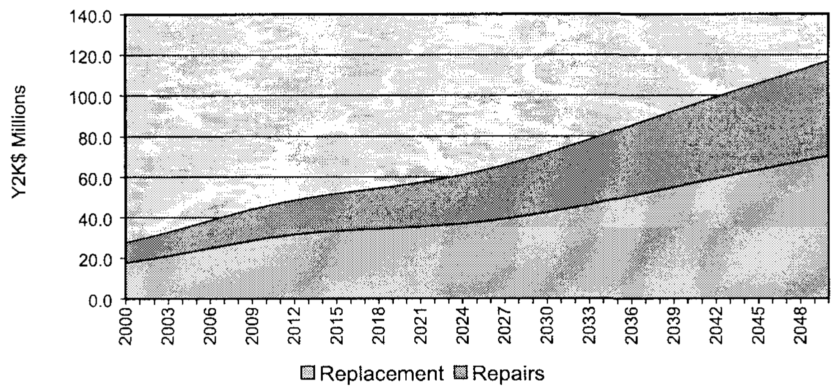
East Bay MUD, Oakland, California

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $8,110 M

Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)



Projected Total Expenditures Due to Wear-Out



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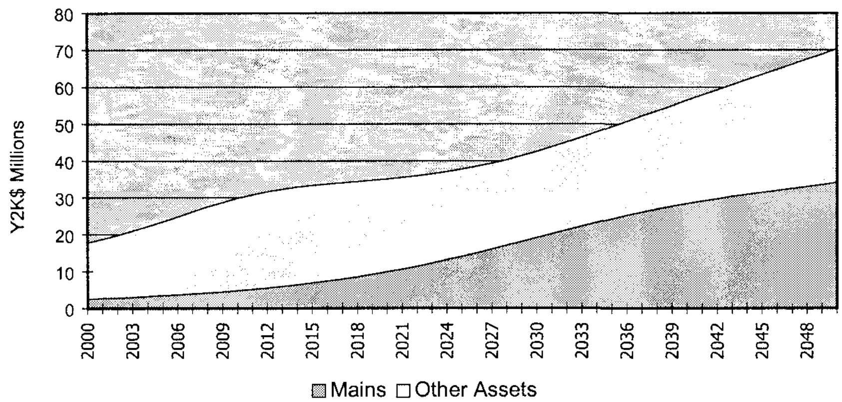
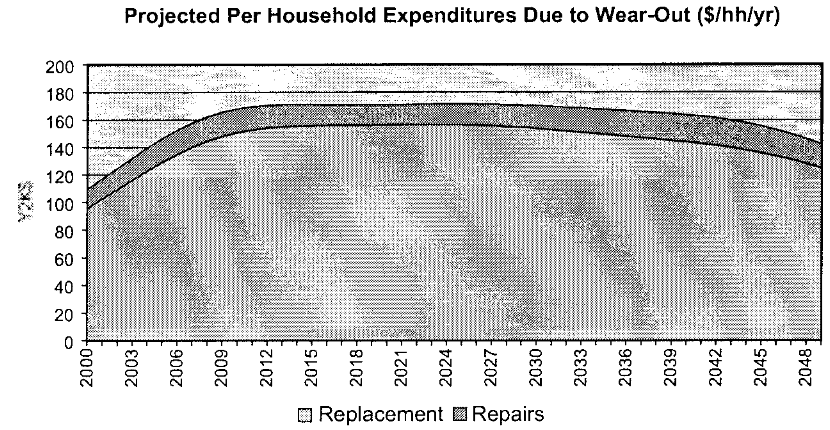
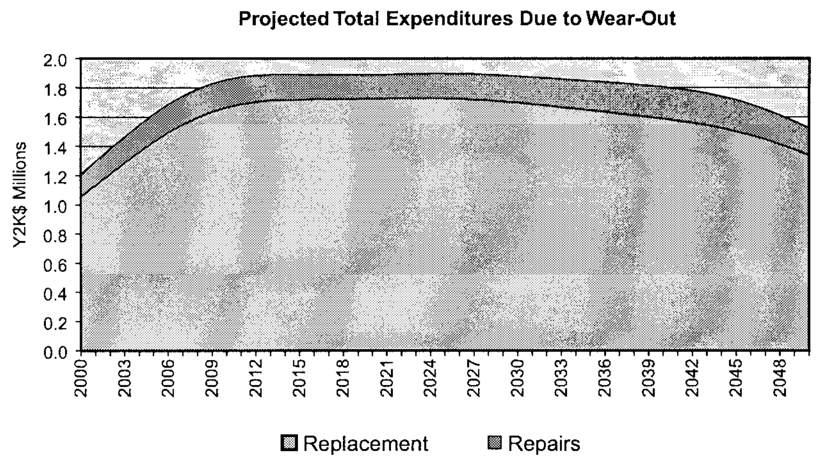
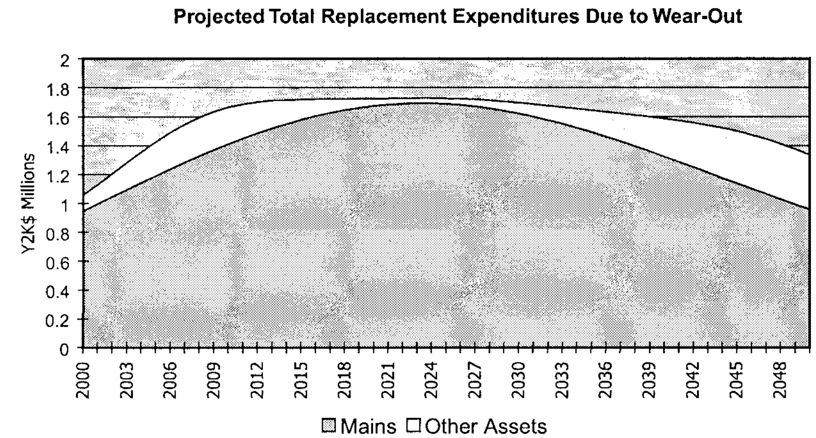


Gloucester, Massachusetts

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $116 M







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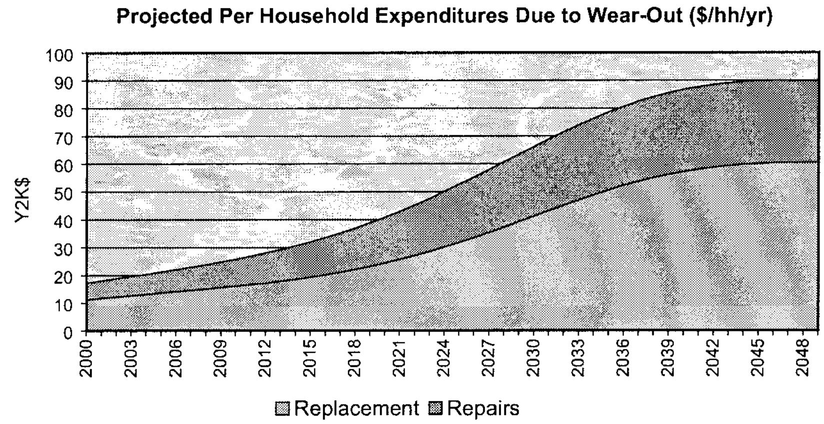
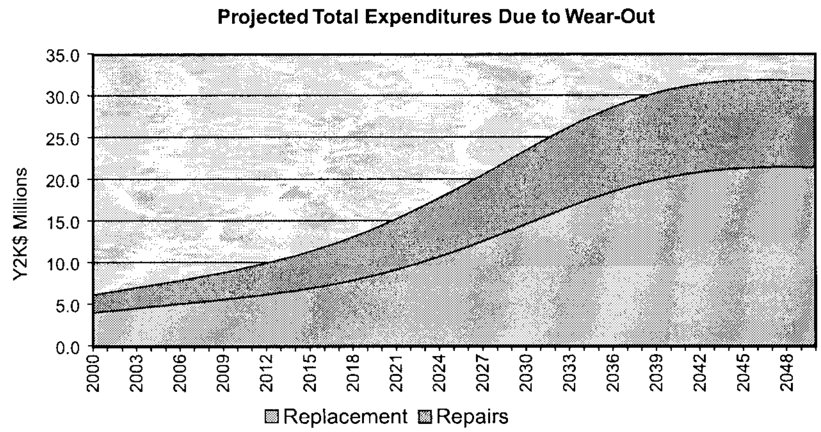
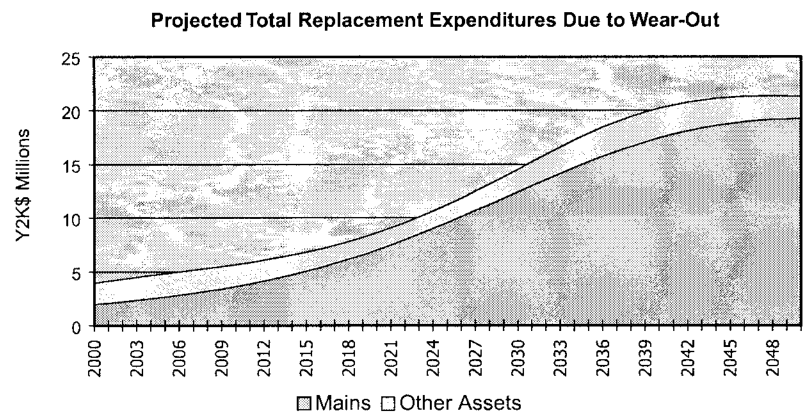


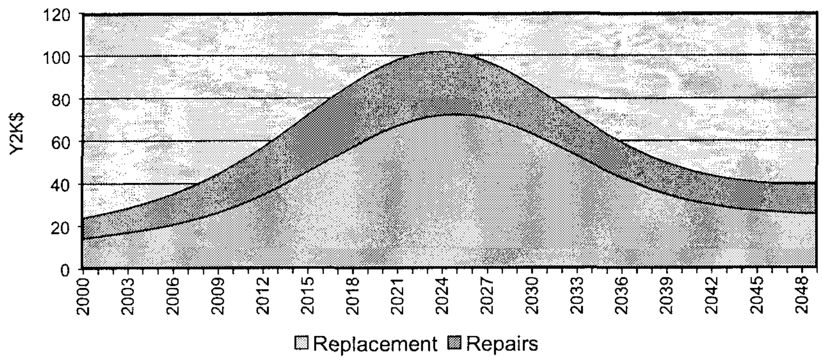




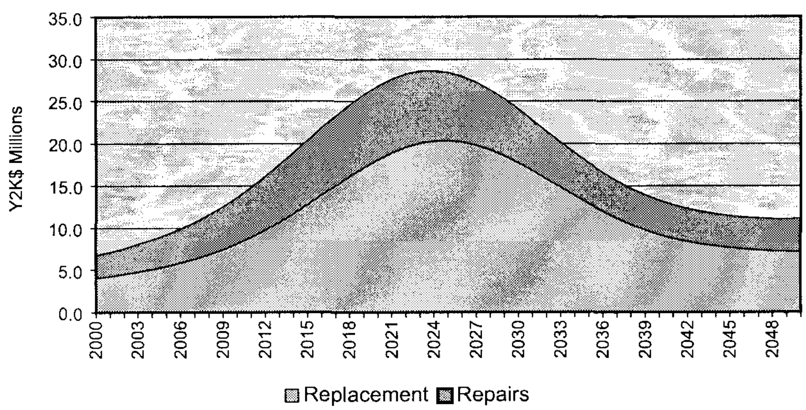
Louisville, Kentucky

Asset Sets Modeled: Water Mains — Estimated Replacement Value $1,343 M

Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)



Projected Total Expenditures Due to Wear-Out



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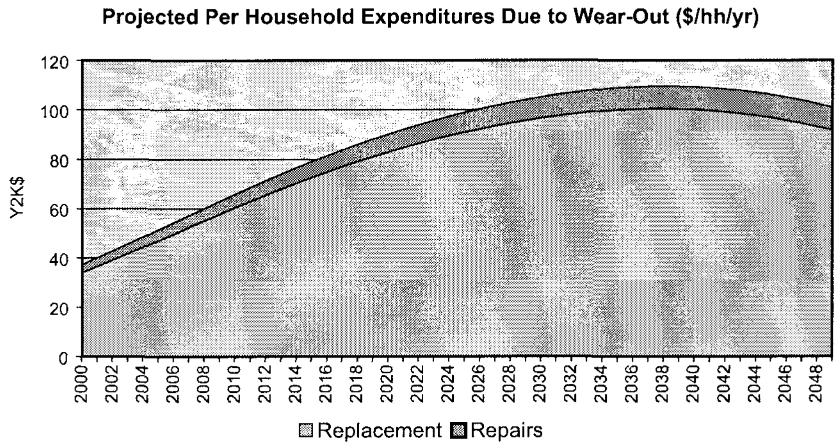
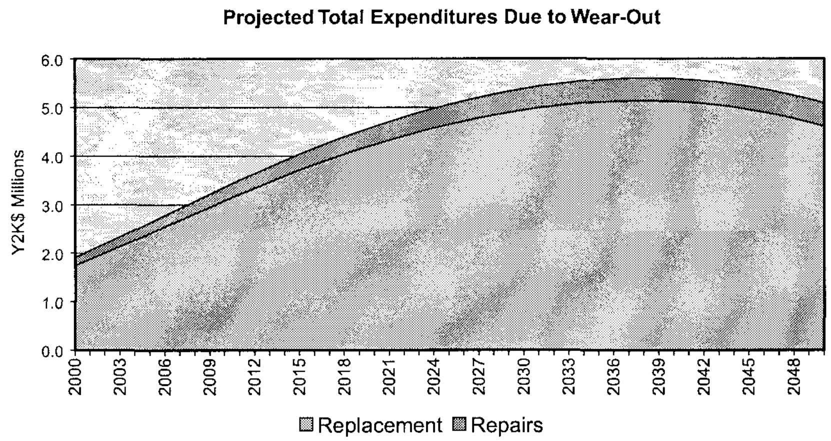
Asset Sets Modeled: Water Mains — Estimated Replacement Value $325 M





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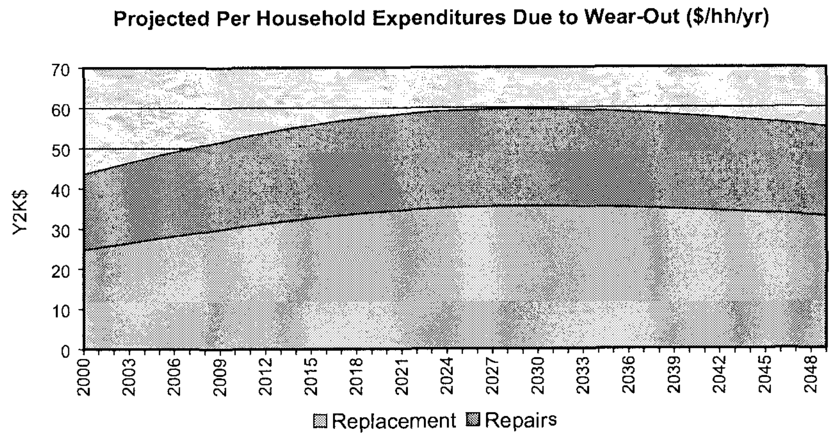

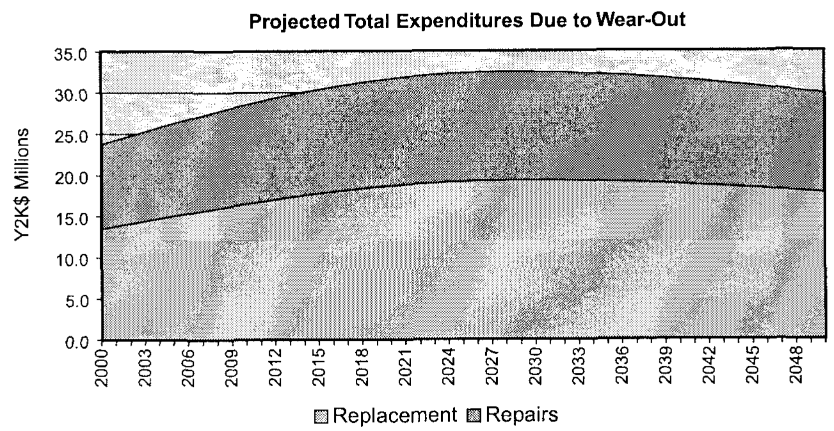

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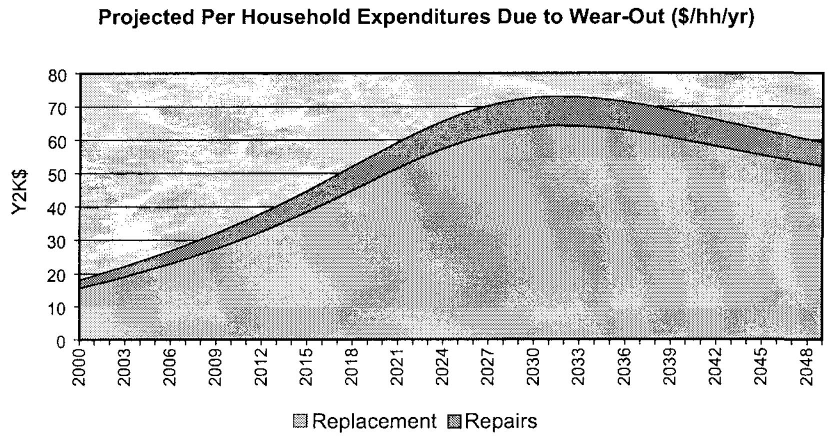
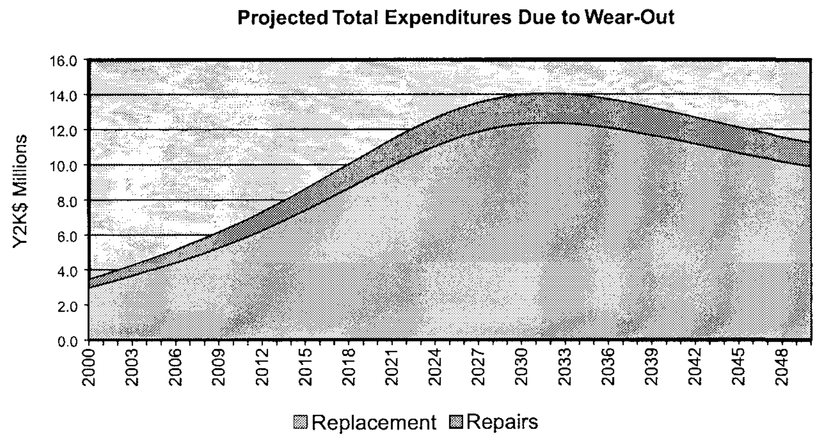
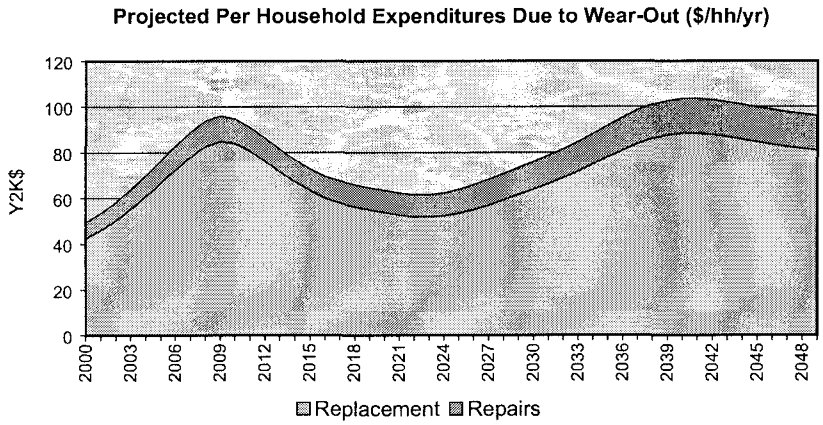
Asset Sets Modeled: Water Mains — Estimated Replacement Value $1,257 M

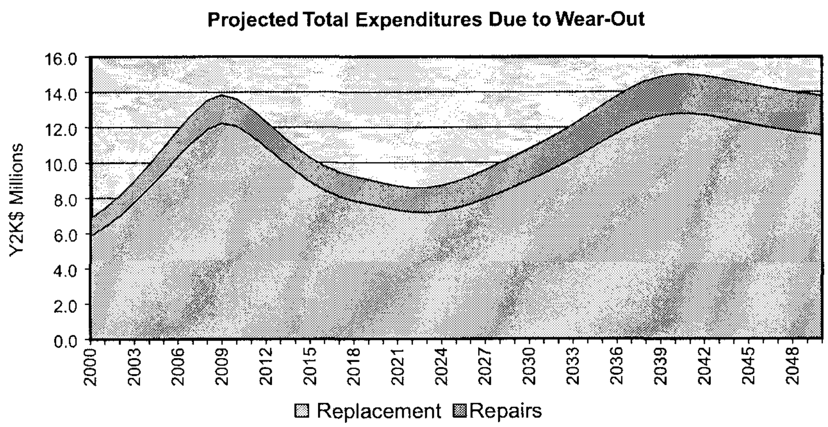


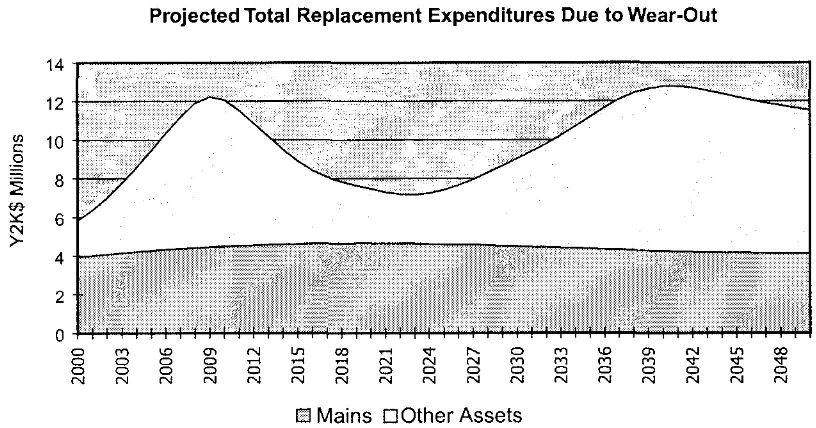


St. Paul, Minnesota

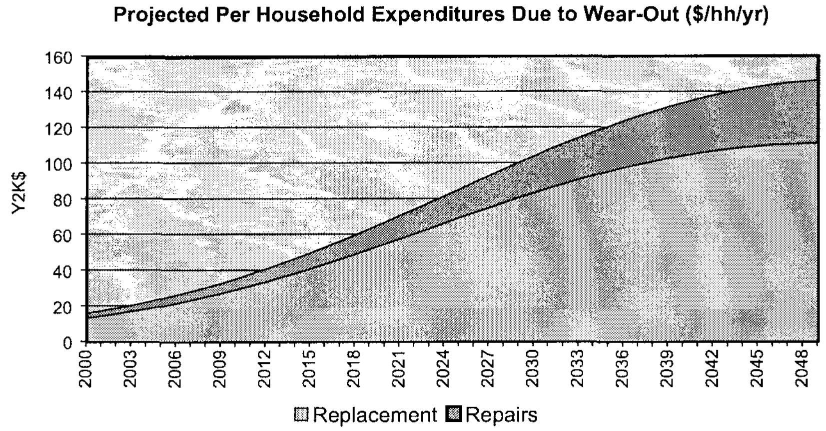
Asset Sets Modeled: Water Mains & Water Supply Plant —
Estimated Replacement Value $1,005 M

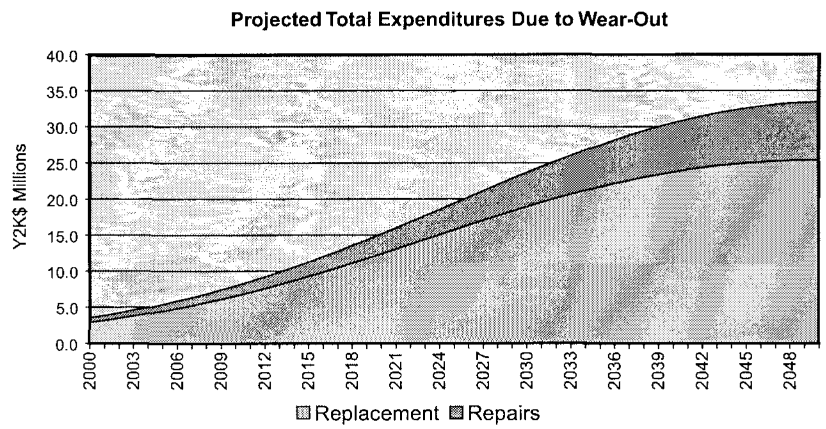






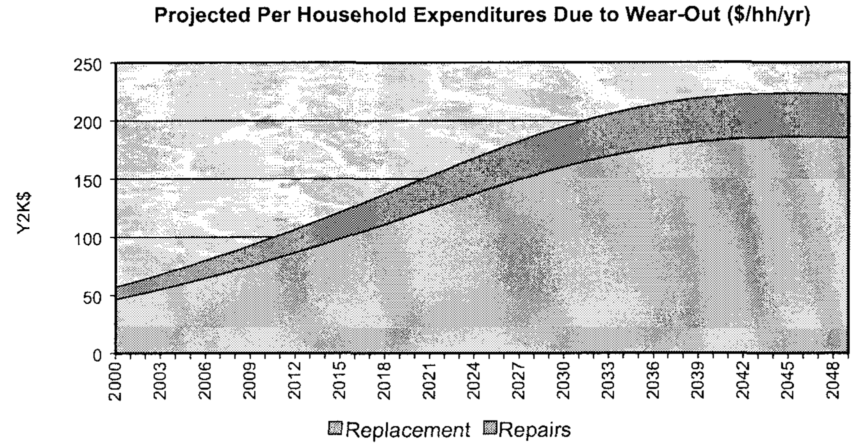
Asset Sets Modeled: Water Mains — Estimated Replacement Value $1,713 M

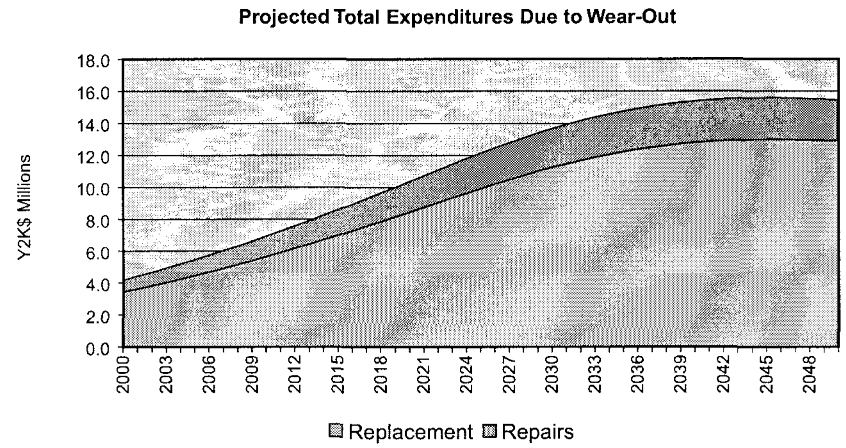


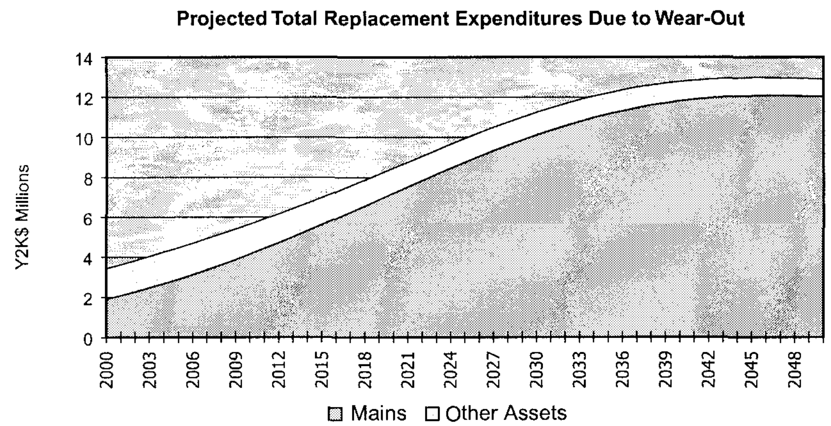


Tacoma, Washington

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $1,100 M



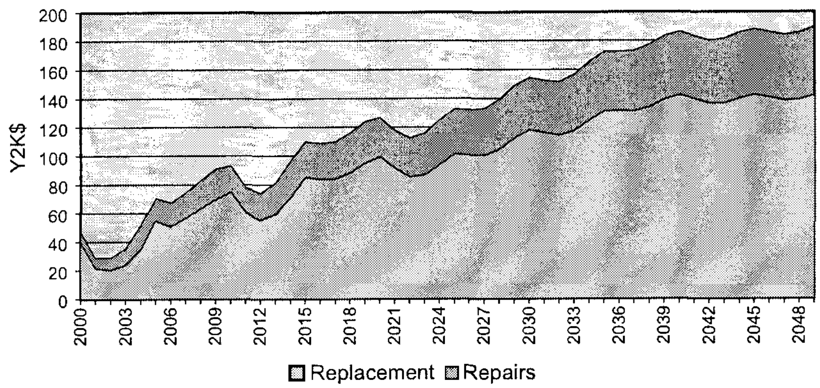




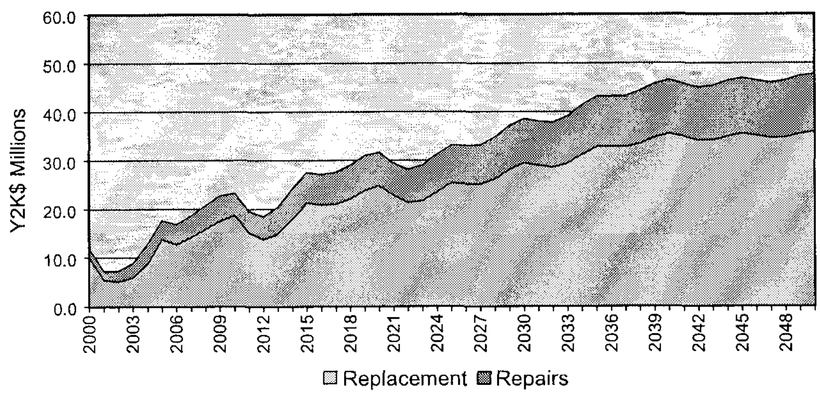
Tucson, Arizona

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $1,852 M

Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)



Projected Total Expenditures Due to Wear-Out



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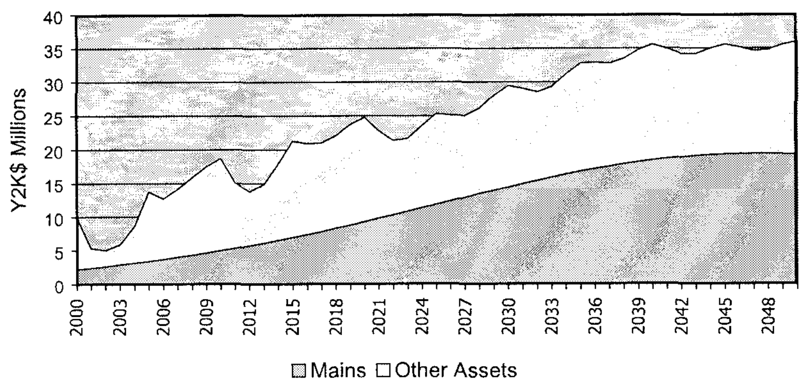
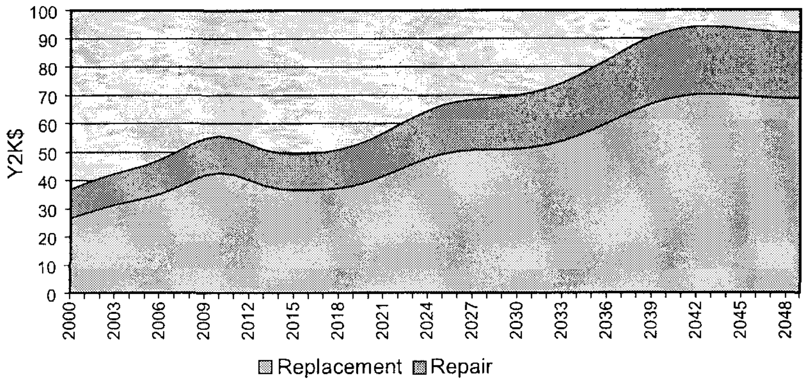


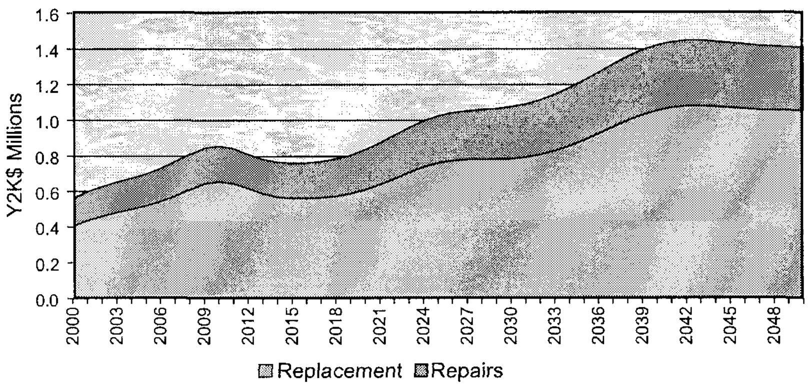
Wausau, Wisconsin

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $84 M

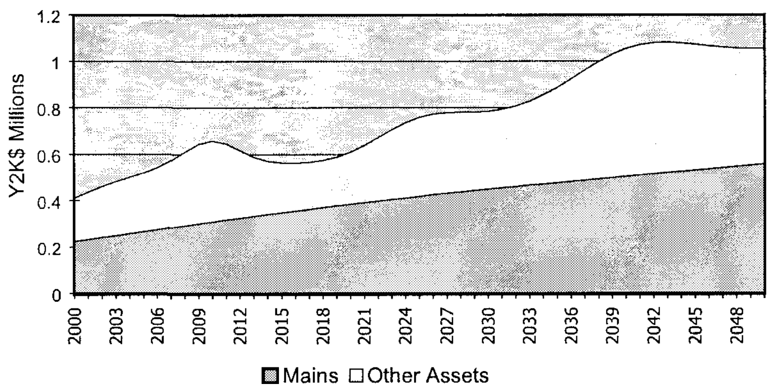
Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)



Projected Total Expenditures Due to Wear-Out



Projected Total Replacement Expenditures Due to Wear-Out



APPENDIX B

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Cincinnati, Ohio

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Denver, Colorado

Des Moines Water Works
Des Moines, Iowa

East Bay Municipal Utility District
Oakland, California

City of Gloucester
Gloucester, Massachusetts

Board of Water Supply
Honolulu, Hawaii

Louisville Water Company
Louisville, Kentucky

United Water New Rochelle
New Rochelle, New York

Philadelphia Water Department
Philadelphia, Pennsylvania

Portland Water Bureau
Portland, Oregon

St. Paul Regional Water Services
St. Paul, Minnesota

Seattle Water
Seattle, Washington

Tacoma Public Utilities
Tacoma, Washington

Tucson Water
Tucson, Arizona

Wausau Water Works
Wausau, Wisconsin

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National Regulatory Research Institute

The Water Industry at a Glance

David Denig-Chakroff, Director
Water Research and Policy
National Regulatory Research Institute

April 2008

Table of Contents

The Water Industry at a Glance

I. Introduction

This document provides a brief summary and description of the drinking water industry in the United States. **Part II** is an overview of the structure of the industry, including numbers, sizes and ownership status of water systems. **Part III** describes physical, technical, and chemical aspects of drinking water systems, including sources of drinking water, physical infrastructure and its security, water quality and water treatment processes. **Part IV** looks at the regulatory roles of the federal government, state environmental and resources agencies, and state regulatory commissions. **Part V** discusses five key issues facing the water industry and regulatory commissions that have jurisdiction over water systems.

II. Industry Structure Overview

There are 156,000 "public" drinking water systems in the United States, serving over 306 million people.[1] The U.S. Environmental Protection Agency (EPA) defines "public water system" as "a system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least fifteen service connections[2] or regularly serves at least twenty-five individuals." Public systems provide drinking water to about 90% of the U.S. population. The remaining 10% are primarily served by individual private wells.

A. Ownership

About 70% of public water systems are privately owned.[3] About 20% are owned by local governments (e.g., cities, counties, towns or villages). The remaining 10% are owned by

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[1] All data in Part II come from the U.S. Environmental Protection Agency, Safe Drinking Water Information System (SDWIS), fiscal year 2007 data, http://www.epa.gov/safewater/sdwisfed/sdwis.htm

The phrase "public water system" refers to the concept that water produced by the system is *provided* to the public; the phrase does not refer to the ownership status of the system. "Public" water systems may be owned by a public entity, such as a municipality, or may be owned by a private entity, such as a water company. We discuss ownership in Part II.A.

[2] A "service connection" refers to the pipes, valves, and connectors necessary to connect a customer to a water distribution system to obtain water service.

[3] Private ownership of a public water system refers to ownership by a private entity. That entity may be publically or privately held and may be for-profit or not-for-profit. It may be a private corporation whose principal business is producing and providing drinking water (e.g., a water company), or it may be an entity whose principal business is something else for which providing water meets an integral need (e.g., a mobile home park).

other entities (e.g., state or federal governments, Native American tribes, water districts or cooperatives, or homeowner associations).

Even though most water systems are privately owned, more people are served by water systems owned by local governments. Local governments provide drinking water to about 77% of the population served by public systems. Public water systems under private ownership serve about 18% of the population. Systems owned by other entities serve about 5% of the population.

B. Size

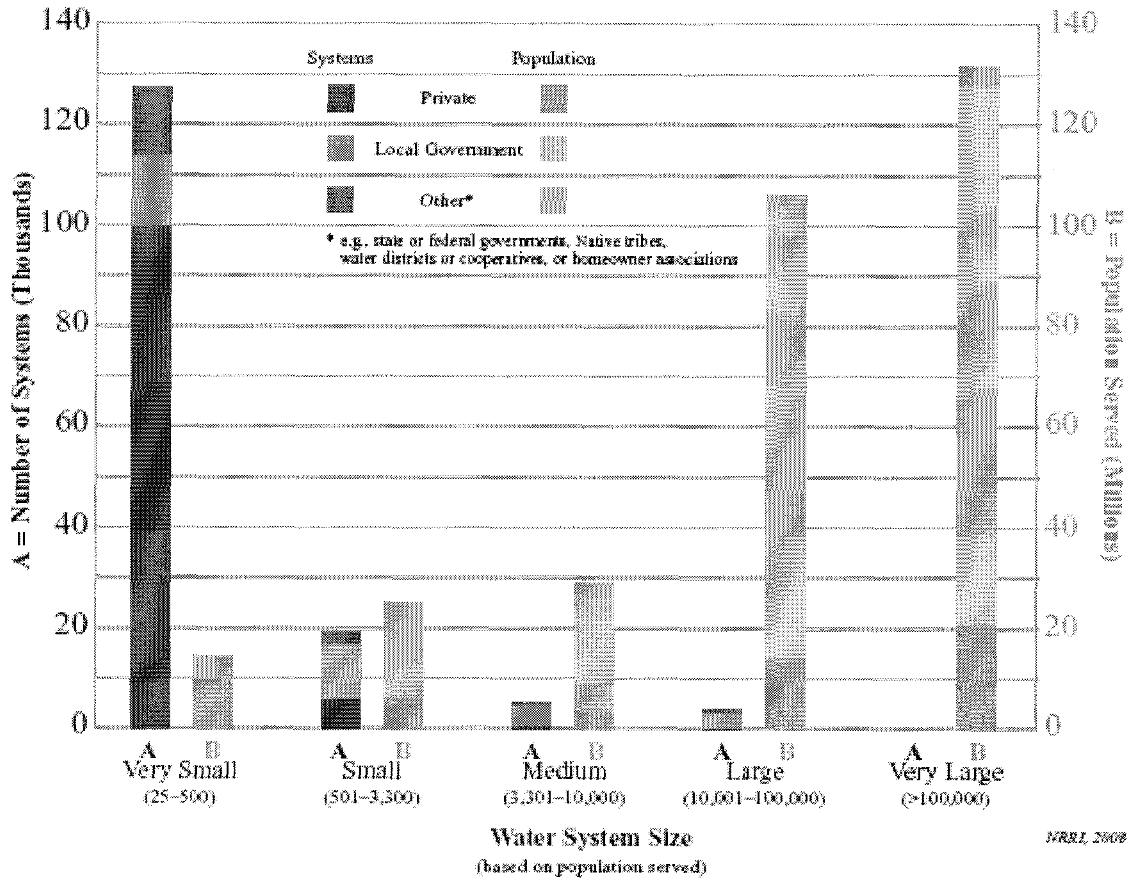
EPA classifies public water systems according to the number of people they serve. Classified as *very small* are systems that serve between 25 and 500 people; *small,* between 501 and 3,300 people; *medium*, between 3,301 and 10,000 people; *large*, between 10,001 and 100,000 people; and *very large*, 100,001 or more people.

Privately owned systems are generally smaller (i.e., serve fewer people) than systems owned by local governments (e.g., cities and counties). Their small size accounts for the fact that a greater number of privately owned systems serve fewer people than systems owned by local governments. The figure on the next page shows the population served by various-size systems under private, local government, and other ownership.

Number and Service Populations of Water Systems by Size and Ownership

		Very Small	Small	Medium	Large	Very Large	Total
Private	Systems	100,153	6,065	681	505	66	107,470
	Population	10,180,224	6,706,056	3,899,880	14,230,568	21,221,469	56,238,197
Local Gov't	Systems	13,805	10,826	3,929	3,055	327	31,942
	Population	2,571,548	15,426,399	22,820,219	87,575,811	106,718,556	235,112,533
Other	Systems	13,231	2,428	434	179	9	16,281
	Population	1,583,135	3,107,577	2,408,429	4,347,855	3,739,630	15,006,626
Total	Systems	127,189	19,319	5,044	3,739	402	155,693
	Population	14,334,907	25,240,032	29,128,528	106,154,234	131,679,655	306,357,356

Source: U.S. Environmental Protection Agency, Safe Drinking Water Information System, 2007



III. Drinking Water Systems

A. Water sources

Drinking water comes from one of two sources. It is either drawn from a ground water aquifer[4] or taken from a surface water body (e.g., river or lake). Small water systems usually pump ground water, while most large water systems use surface water supplies.

1. Ground water use

According to EPA data, about 95% of small and very small water systems use ground water. 60% of medium size systems use ground water. About 40% of large and very large systems use ground water sources.

2. Surface water use

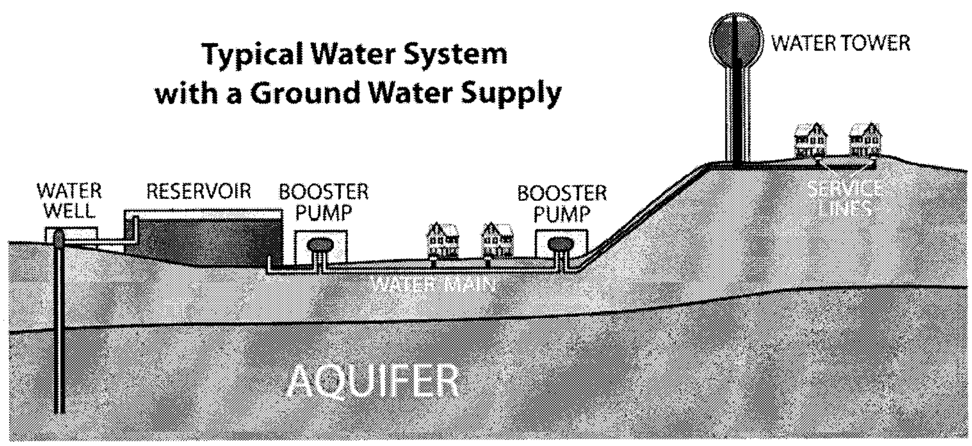
Less than 10% of all water systems use surface water. Because these are the largest systems in the country, however, a majority (65%) of people get their water from a surface water source. About 60% of large and very large systems use surface water sources.

B. Physical infrastructure

1. Extraction methods

a. Ground water systems

Ground water systems drill wells into an aquifer to extract water. A pumping system in the well brings water to the surface where it can be treated and distributed to consumers.



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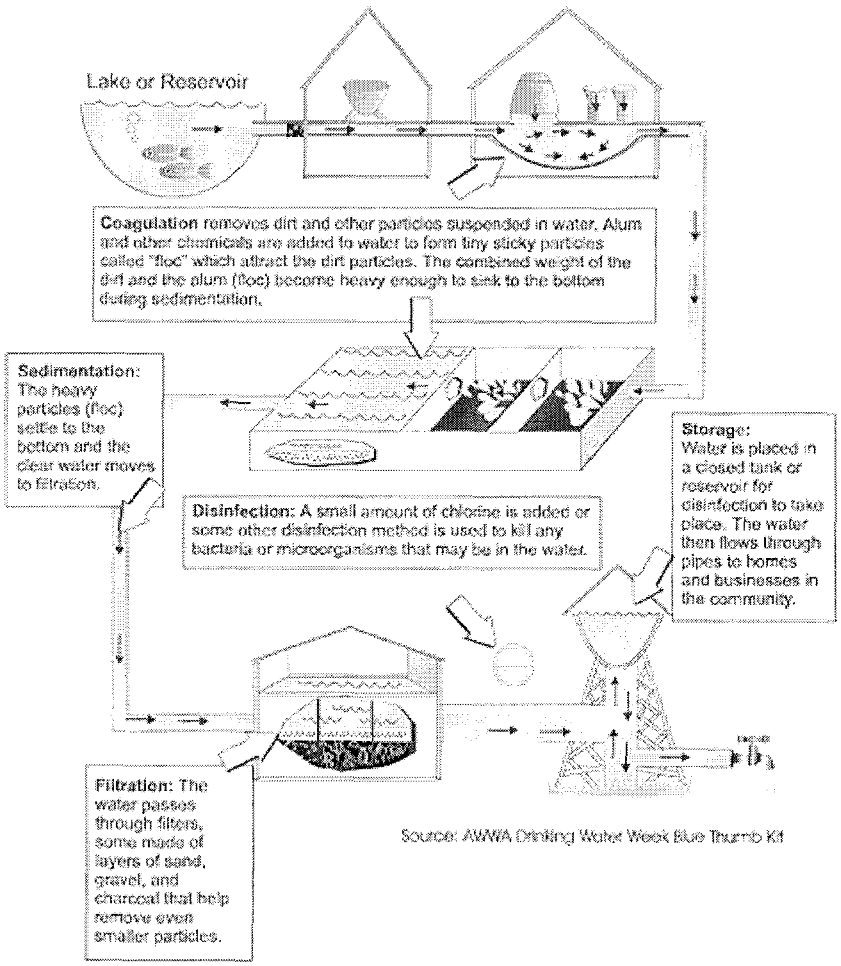
[4] An aquifer is an underground layer or body of water-bearing, permeable rock or unconsolidated material (e.g., gravel, sand, silt or clay) from which ground water can be extracted using a water well.

b. Surface water systems

Surface water systems rely on an intake structure in a surface water body to extract water. The intake consists of a pipe or other water channel through which water flows from the water body to a treatment plant.

2. Treatment systems

Facilities are required for drinking water treatment, which typically consists of coagulation, sedimentation, filtration, and disinfection. Treatment may also include fluoride treatment for the prevention of tooth decay and other treatment processes. (See Part III.C.4 below for more detail about treatment processes.) The diagram below illustrates the facilities and processes included in a typical water treatment system.



Source: AWWA Drinking Water Week Blue Thumb Kit

a. Ground water systems

Ground water systems generally require less water treatment than surface water systems. Ground water is usually naturally filtered in the rock (e.g., sandstone) formation through which it passes before reaching the well bore where it is extracted. Water obtained from such an aquifer is usually of high quality (i.e., free of contaminants) and therefore needs little or no additional treatment before being provided to consumers. It is, however, usually treated with low levels of chlorine as a disinfectant to prevent microbial growth as it travels through water mains to customers' taps. Chorine treatment normally occurs in the same facility that houses the well, before the water is pumped to a storage reservoir. If fluoride is added to the water, it is added at the same time and location as the chlorine treatment.

b. Surface water systems

Surface water systems require facilities for coagulation and sedimentation, as well as manmade filter systems for drinking water treatment. Compared to ground water systems, surface water systems usually require more extensive disinfectant and, possibly, other treatment since surface water supplies are more susceptible to contamination. Like ground water systems, chlorine is added to maintain disinfection as the water moves through the distribution system.

c. Ground water under the influence of surface water

"Ground water under the influence of surface water" refers to a situation in which a well is used to extract water from the ground, but there is a direct connection between the aquifer and surface water sources. Under these conditions, there is little if any protection of the ground water from potential contamination sources at the surface. For the purposes of treatment and water quality regulation, such water sources are treated as surface water systems.

3. Water storage

Drinking water utilities maintain treated water in storage until it is needed to meet demand. If chorine is the disinfectant treatment, storage reservoirs also serve to allow sufficient contact time between water and chlorine for proper disinfection before water is distributed to customers. The amount of storage needed for any given system is driven primarily by instantaneous demand requirements for fire protection.

4. Pumps and pressure

Pressure is needed to move water through a water system. *Hydraulic head* is a measurement of water pressure, based on the weight of a column of water. When left unrestricted, water will move from a point of higher hydraulic head to a point of lower hydraulic head. The difference in pressure between the two points is the *hydraulic gradient*.

Water utilities typically maintain system pressures between 30 and 100 pounds per square inch (psi) at customers' taps. Below this range, there would be insufficient water pressure for normal use. Above this range, water pressure could damage the seals and gaskets in plumbing fixtures that prevent the fixtures from leaking. Utilities control system pressures through the use of pumps, storage reservoirs, water towers, and pressure-reducing valves.

Within a water system, both pumps and gravity are used to create hydraulic head, which maintains system pressure and moves water from Point A to Point B. If a storage reservoir or water tower is at a higher elevation than the customers it serves, gravity may create sufficient head to move the water from the reservoir or tower to the consumer. If there is insufficient elevation to create a proper hydraulic gradient, booster pumps may be used to increase the hydraulic head. Booster pumps may also be used to lift water into an elevated storage tank or water tower. The force of gravity on the stored and elevated water then applies consistent pressure for the water system.

5. Water mains

Water mains are the pipes through which water is distributed from supply and treatment facilities to utility customers. The term *distribution system* refers to a utility's system of water mains. Water mains are usually buried in rights-of-way and beneath streets. They are typically 6 inches to 24 inches in diameter, depending on the water flow volumes needed to meet demand at different points in the system. Flow volumes needed for fire protection are the highest volumes required of water systems. Fire flow needs, consequently, dictate the size of water mains.

Broken and leaking water mains are a normal part of water system maintenance. The condition and reliability of water mains depend on many factors, such as age, pipe material, pipe size, type of soil in which it is buried, and the corrosivity of water.

Pipe material and manufacturing techniques have changed over time. Following World War II, for example, the lack of availability of iron resulted in lower-quality water mains. In many cities, some cast iron water mains are still in service after 100 or 150 years, while mains installed only 50 or 60 years ago have reached the end of their useful lives.

There is a great deal of variability in the stability of the unconsolidated deposits (e.g., soils, sand, silt, and clay) in which water mains are buried. Unstable deposits can result in movement and breakage of the pipe. In cold climates, mains are buried deep enough to be below the frost line to minimize freezing and frost heaving, but main breaks and leaks are still a common occurrence.

6. Service lines and meters

Service lines, or "laterals," are smaller-diameter pipes tapped into a water main, running perpendicular to the water main. They carry water from the main to individual customers. Typical residential service lines range from ⅝-inch to 1-inch diameter.

Different states handle the ownership of service lines differently. In most states, the portion of the service line from the water main to the property line is owned by the water utility, and the portion from the property line to the home or business is owned by the property owner. Typically there is a shut-off valve at or near the property line that demarcates the change in service line ownership. In some states, however, the water utility owns the service line from the water main to the home or business. In others, the property owner owns the entire service line.

Utilities install water meters on service lines to measure, for billing purposes, the amount of water used by customers. The meter may be located in a pit at or near the property line. In cold climates where meters would freeze in an outside pit, they are installed at the end of the service line inside the customers' basements.

7. Security[5]

The Safe Drinking Water Act of 1974 (SDWA)[6] and its amendments is the major federal law that provides for the quality and safety of the nation's drinking water. It also regulates the public water supply and its sources. The SDWA established the first mandatory national program designed to protect public health by providing for safe drinking water.

Following the terrorist attacks of September 11, 2001, The *Public Health Security and Bioterrorism Preparedness and Response Act of 2002* (Bioterrorism Act)[7] and a series of Homeland Security Presidential Directives (HSPD)[8] expanded upon and further defined responsibilities for the safety and security of drinking water supplies and infrastructure. The Bioterrorism Act and presidential directives gave EPA responsibility for: (1) assessing vulnerabilities of water utilities, (2) developing strategies for responding to and preparing for emergencies and incidents, (3) promoting information exchange among stakeholders, and (4) developing and using technological advances in water security.

Under EPA rules promulgated in response to the Bioterrorism Act and presidential directives, water utilities serving more than 3,300 people were required to assess their vulnerabilities to terrorist attack and to prepare emergency response plans. EPA has also established the Water Security Initiative, which addresses the risk of intentional contamination of drinking water distribution systems, and the Water Sector-Specific Plan (Water SSP). The Water SSP is a water critical-infrastructure protection strategy developed under the Department of Homeland Security's National Infrastructure Protection Plan. The Water SSP provides utilities with information on goals, identifying assets, assessing risk, prioritizing infrastructure, developing and implementing protective programs, measuring progress, and research and development.

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[5] Source for Part III.B.7: U.S. EPA, www.epa.gov/safewter/watersecurity

[6] Pub. L. 93-523; 42 U.S.C. § 300f et seq. December 16, 1974.

[7] Pub. L. 107-188, June 12, 2002.

[8] HSPD-7: Critical Infrastructure Identification, Prioritization and Protection, December 17, 2003.
HSPD-8: National Preparedness, December 17, 2003.
HSPD-9: Defense of United State Agriculture and Food, January 30, 2004.
HSPD-10: Biodefense for the 21st Century, April 28, 2004.

C. Water quality

Drinking water quality depends on a number of factors, including the quality of the source water, the treatment processes applied, conditions in the distribution system, and the application of point-of-use treatment (e.g., home filters). Drinking water quality is regulated at the federal and state levels (see Part IV, below).

Drinking water can become contaminated from a variety of sources. The contamination may occur naturally or as the result of human development and activities. All sources of water have some level of contamination (no water in nature is pure hydrogen and oxygen; i.e., H_20). In fact, some contaminates in water are desirable and necessary for human health. Concern arises, however, when the level of any particular contaminant in drinking water is high enough to pose a risk to human health.

1. Types and sources of contaminants

a. Microbial organisms

Microbial organisms (e.g., bacteria and viruses) are ubiquitous in nature and are found naturally in water. Human activities may also be responsible for the presence of microorganisms in drinking water supplies (e.g., runoff from farm lots, seepage of septic systems, and leaking of sewer pipes).

b. Inorganic compounds

Inorganic compounds (IOC) are salts, metals, and minerals (e.g., arsenic, barium, calcium, fluoride, copper, lead, iron, magnesium, manganese, mercury, nitrate, nickel, sodium). Their presence in water may be naturally occurring or can result from human activity, such as storm water runoff, wastewater discharge or farming. Some IOC, such as lead, copper and iron, can leach from the pipes in a water system. Ground water, in particular, typically has naturally occurring minerals dissolved in it. Water with dissolved IOC (particularly calcium and magnesium) is referred to as *hard water*.

c. Synthetic organic compounds

Synthetic organic compounds (SOC) include pesticides and herbicides, which can contaminate a water source from agricultural activities, storm water runoff or residential uses.

d. Volatile organic compounds

Volatile organic compounds (VOC) are derived from petroleum products or from solvents and cleaners (e.g., benzene, carbon tetrachloride, chloroform, trichloroethylene, trihalomethanes, and vinyl chloride). They may also form as a byproduct when chlorine is added to water that contains organic matter. VOC may get into a water supply through discharges from chemical plants, refineries, factories, dry cleaners and industrial activities.

e. Radionuclides

Radionuclides (e.g., radon and radium) are elements that emit radiation. They can enter drinking water supplies from the decay or erosion of either natural deposits or man-made sources.

2. Protecting water supply sources from contamination

Ground water supplies have more natural protection from contaminants than surface water supplies. They still can become contaminated, however, by seepage of contaminants from the surface through soil and substrate or by leakage of contaminants down improperly sealed well bores.[9] To help prevent contamination of aquifers, many ground water systems have established wellhead protection programs that monitor and restrict development around wells.

The best way to protect surface water supplies is to take a watershed approach.[10] Any potential contaminant in the watershed of a surface water supply has the possibility of contaminating the supply. Water systems routinely identify potential sources of contamination throughout the watershed and monitor those sources to help protect their drinking water supply.

3. Monitoring and testing for contaminants

Federal rules, promulgated by the EPA pursuant to the Safe Drinking Water Act (SDWA), provide standards for over 80 potential contaminants that may occur in drinking water and pose a risk to human health. The rules provide maximum contaminant levels (MCLs)—the highest level a contaminant may be present in drinking water—and other standards to minimize health risk. The federal rules are binding on all public water systems.

The federal rules require all public water systems to monitor and test for potential contaminants on a regular basis to ensure that their drinking water meets federal standards. The tests determine whether and how the water needs to be treated to meet standards for consumption, as well as the effectiveness of existing treatment processes.

4. Water treatment processes

Treatment processes for drinking water vary depending on the purity of the source water and on the type and amount of contaminants present. (See diagram above in Part III.B.2 for common processes.) In general, they may consist of any one or more of the following:

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[9] The top portion of a well bore is cased and sealed to prevent contaminants on or near the surface from moving down the well bore and contaminating the well. If improperly cased or if the seal deteriorates over time, a well bore itself may act as a conduit for contamination.

[10] A *watershed*, also referred to as a *drainage basin*, is the area of land from which water (from rain or snow melt) drains into a particular body of water (e.g., a river, lake or aquifer that serves as a drinking water supply).

a. Coagulation and sedimentation

A coagulant is a substance (e.g., alum) that is added to water to attract solid matter. The coagulant removes the solid matter from suspension by causing it to settle to the bottom of a sedimentation chamber. The clear water, free of large particles, then is drawn from the top of the chamber for filtration.

b. Filtration

Water passes through filters to remove small particles that cannot be removed by coagulation and sedimentation. Even microscopic organisms such as viruses and bacteria can be removed through filtration.

c. Ion exchange

This process removes inorganic contaminants (IOC) that cannot be removed adequately with sedimentation or filtration. The most common form of ion exchange water treatment is the household water softener used to treat hard water.

d. Absorption

Organic contaminants and compounds that cause undesirable color, taste and odor can be removed from drinking water through absorption onto the surface of granular or powdered activated carbon.

e. Air stripping

Volatile organic compounds (VOC) can be removed from drinking water with this treatment, which creates a water spray to maximize the exposure of water particles to air, causing VOCs to be released from the water into the air.

f. Disinfection

One or more disinfection methods (e.g., chlorine, chloramines, chlorine dioxide, ozone and ultraviolet radiation) are applied to kill bacteria or microorganisms that may be in the water. The final disinfection method in any treatment system is typically chlorination, which provides a chlorine residual in the water as it moves through the distribution system. The chlorine residual kills any microorganisms that may get into the water in the distribution system or in a home plumbing system.

g. Fluoridation

Some water systems add fluoride to the drinking water as a treatment to reduce tooth decay in their community.

h. Point-of-use (POU) systems

POU treatment is any water treatment at the home or business where it is consumed. Businesses such as food processors may want additional treatment to meet quality standards that exceed federal drinking water standards. Many homeowners elect to maintain POU treatment in the form of a home filter system. POU treatment is particularly effective in some water systems for improving water aesthetics (i.e., color, taste, and odor) by removing minerals (e.g. iron and manganese) that can come out of solution and form suspended particles as the water moves through the distribution system.

IV. Drinking Water Regulation

A. U.S. Environmental Protection Agency (EPA)

The Safe Drinking Water Act (SDWA) was passed by Congress in 1974 and later amended in both 1986 and 1996. The law requires the EPA to establish national health-based standards for drinking water to protect against contaminants (both naturally occurring and man-made). Amendments to the SDWA include expanded requirements for the EPA to establish rules for source water protection, operator certification, funding water system improvements, and providing public information. The Bioterrorism Act of 2002 and subsequent presidential directives (discussed in Part III.B.7 above) require the EPA to regulate public water system vulnerability assessments and emergency response plans.

B. State environmental and natural resources agencies

Direct oversight of EPA requirements for public water systems is conducted through state drinking water programs. States that adopt standards at least as stringent as the federal standards can obtain authority from the EPA to implement the SDWA within their jurisdictions. The state agencies responsible for this oversight (typically a state environmental or natural resources agency) are referred to as "primacy" agencies, since they have primary responsibility for enforcing the SDWA.

C. State regulatory commissions[11]

Forty-six state commissions regulate water utilities. These commissions, however, only regulate about 20% of all public water systems. The types of water utilities that are regulated and the scope of commission authority over those utilities vary from state to state.

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[11] Data and other information in Part IV.C come from: Beecher, Janice A., *1995 Inventory of Commission-Regulated Water and Wastewater Utilities*, School of Public and Environmental Affairs—Indiana University, Pub. No. 95-E18, November 1995.

Dr. Beecher (now with the Institute of Public Utilities at Michigan State University) is currently working on a project to update this data. This section will be updated when new information becomes available.

1. Ownership of regulated utilities

All 46 states that regulate water utilities regulate privately-owned systems. Eleven states regulate some or all municipally-owned water systems. Twelve states regulate water systems under other ownership (e.g., cooperatives, water districts, homeowner associations).

State regulatory authority over non-private water utilities is often limited. A municipal water utility, in some states, may only be regulated if it extends service outside the municipal boundary. Customers outside the municipality may have little, if any, political input or control over their service provider. State regulation provides assurance that costs and services are fair and reasonable in such cases. In some states, municipalities may choose whether or not to be regulated by their state commission. About one-third of states provide an exemption from regulation to utilities under a specified size.

2. Scope of regulatory authority

All 46 commissions that regulate water utilities have authority to set utility rates and require annual financial and operating reports. Forty-five out of 46 states initiate financial audits. Forty-four review mergers and acquisitions and hear customer complaints. Forty-one require management audits and have authority over financial issuances of the utility. About three-quarters of commissions certify new systems and authorize service areas and expansions. Just over half the commissions can also require utilities to conduct forecasting and planning processes. Some commission scope of authority is limited further. In some states, for example, commissions may only require certain types of information (e.g., financial plans and demand forecasts) as part of an active rate case.

These data indicate that many state commissions lack regulatory control in areas such as certifying new systems, approving service area expansion, and requiring forecasts and plans. Such lack of authority may limit a commission's ability to address a number of issues facing water utilities and their customers.

V. Key Issues

This section describes some issues facing water utilities and regulatory commissions. It is not meant to be a comprehensive list or a thorough discussion of the issues. It provides a short description of a few key issues that regulatory commissions are facing or are likely to face. Additional information about these issues may be found in the NRRI sources cited.

A. Small water systems[12]

[12] Source: Stanford, Melissa J., *Small Water Systems: Challenges and Recommendations*, NRRI, Pub. 08-02, February 7, 2008.

Ninety-four percent of public water systems in the U.S. are classified by EPA as small or very small (serving less than 3,300 people). Seventy-three percent of those systems are privately owned and likely regulated by a state commission. Many small water utilities struggle to achieve economies of scale, financial stability, managerial excellence and technical proficiency. They have difficulty operating effectively and efficiently, maintaining their equipment and infrastructure, complying with federal and state regulations, providing reasonable rates and high standards of customer service and, in some cases, simply staying in business. Despite federal programs such as the Drinking Water State Revolving Fund (DWSRF) and the capacity development provisions of the SDWA amendments of 1996,[13] problems persist for small water systems. The situation is likely only to worsen as infrastructure replacement needs increase and as new regulatory requirements demand increased investment in water systems.

Some state commissions have implemented effective practices, policies, procedures and regulations to assist small utilities and their customers. These include: (1) providing technical assistance and advice, (2) simplifying rate procedures, (3) modifying rate designs and structures, (4) establishing policies to advance consolidation and regionalization, (5) strengthening certification requirements for new small systems, and (6) working closely with primacy agencies and other stakeholders to improve small system conditions.

The challenges for state commissions in addressing small water system issues cannot be solved through rate cases alone. Strong and creative involvement by commissions and their staff is needed. Whatever alternatives are used by state commissions to help small systems, essential elements of a lasting solution include: (1) improved communication between state commissions and small utilities; (2) improved working relationships between commissions and other regulatory agencies and stakeholders; (3) increased small water utility attention to economies of scale; (4) small system managers accessing and using the tools available to assist them; and (5) sufficient state commission authority and resources to implement the policies, procedures, regulations, and standards needed.

B. Water conservation, efficiency, and sustainability[14]

Water conservation programs have become commonplace across the country, even in areas with relatively abundant water supply. In arid western states, water conservation has become a necessary fact of life. Other areas of the country frequently experience periodic short-term drought that trigger water conservation measures, especially during hot summer months. Regions that have not experienced long-term drought are not exempt, as experienced by Atlanta, Georgia in 2007. Some of the fastest growing areas in the country, such as Las Vegas, Nevada,

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[13] The DWSRF is a loan fund established by the SDWA and administered by state primacy agencies for the purpose of providing funding to utilities for infrastructure improvement, training, source water protection, and capacity development. Capacity development refers to SDWA provisions requiring evaluation and improvement in the technical, financial and managerial capacities of drinking water utilities.

[14] Source: NRRI, *Water and Wastewater Research Agenda*, February 5, 2008, pp. 7-9.

are in areas with very limited water supply. The effects of global climate change threaten to create water shortages in areas that have not previously been affected.

In addition to helping sustain water supplies, water conservation programs defer construction of new facilities. Growing communities can delay construction of wells, storage reservoirs and treatment systems if they reduce their per capita water demand.

The great majority of water utility costs are fixed costs, such as payroll, benefits, and debt service associated with capital assets. Water conservation programs do little to reduce existing fixed costs of a utility (although they can defer, as just explained, "future fixed costs"). Traditional rate structures recover fixed costs through variable charges (i.e., dollars per gallons of water sold). Under traditional rate structures, therefore, water conservation reduces a utility's ability to recover its fixed costs.

Water utilities and state commissions must look for innovative ways to promote and gain the benefits of water conservation and efficiency while maintaining financial stability. This can be accomplished through supply-side techniques, demand-side programs and rate structure and design.

C. The water-electric nexus[15]

Producing and delivering safe drinking water is a power-intensive operation, involving extensive use of pumps and treatment systems. Generating electricity uses large quantities of water, primarily for cooling. Consequently, reducing water use reduces demand for electricity, and reducing electric demand in turn reduces use of water.

Water systems are often one of the biggest power users in their communities. Power costs are typically a major budget item for water and wastewater utilities. Water and wastewater operations account for 19% of the total annual power use in California. Reduction of power use in the water sector would thus have a measurable effect on reducing electric demand and would simultaneously improve efficiency and reduce costs of water operations.

Regulatory commissions and utilities that can promote water conservation through supply-side (e.g., distribution system leak detection and repair) and demand-side (e.g., low-flow fixture promotion) programs will also have a positive effect on energy efficiency. The effectiveness of water conservation programs should always include an evaluation of their effect on energy use.

D. Infrastructure replacement and asset management[16]

Surveys conducted by EPA suggest that the need for water and wastewater infrastructure improvement and replacement (both privately and publicly owned) over the next 20 years is

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[15] Source: NRRI, *Water and Wastewater Research Agenda*, February 5, 2008, pp. 9-10.

[16] Source: NRRI, *Water and Wastewater Research Agenda*, February 5, 2008, pp. 1-4.

between $500 billion and $1 trillion. This dollar level reflects a growing need across the Nation to replace water and sewer pipes and other water and wastewater facilities as they approach the end of their useful lives.

The reason for this surge in infrastructure needs stems from the population boom and economic growth at the end of World War II. During those post-war years, there was unprecedented industrial, business, commercial and residential development, along with the water and wastewater infrastructure to support it. That infrastructure is now reaching the age when it is beginning to wear out and needs to be upgraded or replaced. Water and wastewater utilities need to manage those assets actively or risk adverse economic consequences, such as unplanned system failures, increased maintenance costs, and unbudgeted repair and replacement costs. Depending on the length of the useful life of various components, the need to replace this infrastructure will continue over the next several decades.

Many utilities have conducted plans consisting of a complete assessment of utility facilities and assets, including a determination of the condition and remaining useful life of each component of the system, right down to each segment of buried pipe. Components of the system are also rated in terms of criticality for operation of the system. A model is often developed based on asset condition, criticality and other relevant factors to prioritize the infrastructure replacement and improvement needs over time. Costs are then applied to determine reinvestment needs over time.

The goal of these plans is to determine a reinvestment timeline that will allow continued operation of critical infrastructure throughout its useful life, but will ensure replacement before it fails and before maintenance costs increase dramatically. Planners then can prepare infrastructure replacement schedules and budgets that will spread out the costs of improvements over a pre-established planning horizon. This scheduling and budgeting will avoid unplanned maintenance and capital costs to the utility while maintaining efficient operation of the system.

This situation poses several challenges for utilities and regulatory commissions. One challenge is how to finance the necessary infrastructure replacements such that (a) rates increase gradually (as opposed to sudden spikes in rates), while (b) maintaining the utilities' financial stability. A second challenge is ensuring that the large expenditures are made prudently, so as to win and sustain customer trust and political credibility. Adding to the challenge is the absence, for most utilities, of a designated fund available to replace aging infrastructure—an absence attributable to ratemaking practices which have kept depreciation rates low and have disallowed or discouraged rate recovery of contributions in aid of construction.

E. Water quality[17]

The SDWA provides that EPA may grant a state primary enforcement responsibility if the state adopts drinking water regulations that are no less stringent than federal rules. If a state does not adopt such regulations, EPA will enforce the federal rules in that state. A state with primacy status may adopt regulations that are more stringent than federal rules.

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[17] Source: NRRI, *Water and Wastewater Research Agenda*, February 5, 2008, pp. 1-4.

Some local (i.e., substate) jurisdictions establish water quality standards that are more stringent than both federal and state standards. Utilities and local officials can choose to enforce the federal guidelines or their own standard. They might enforce a stricter standard to increase public confidence in the drinking water system.

State utility commissions are responsible for utility rate setting and quality of service issues. When they issue certificates of public convenience for water treatment systems and when they rule on rate hikes for capital investment and operating expenses related to water quality, they are affecting water quality decisions by determining what cost levels are appropriate for the community.

Federal agencies, state environmental and resource agencies, state regulatory commissions, local governments and utilities all have some say in making and enforcing drinking water quality standards in a community. Lines of authority, however, are not always clear, and decisions by these various agencies are not always coordinated, consistent or fully informed.

Drinking water quality concerns have become more pronounced. Customers and community leaders have become better informed and more vocal about water quality standards. These factors have increased the need for regulatory commission involvement in water quality issues. Utilities are increasingly seeking rate recovery and construction approvals for water quality activities and facilities. Commissions and their staff need to be well informed about water quality problems and concerns and the most effective utility responses so they can make optimal decisions.

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FINANCING MECHANISMS FOR CAPITAL IMPROVEMENTS FOR REGULATED WATER UTILITIES

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EXECUTIVE SUMMARY

Due to factors that include the needed replacement in many parts of the United States of an aging water distribution infrastructure, compliance with the amended Safe Drinking Water Act, and growing water demands associated with economic development and urban growth, the magnitude of required capital improvements in water supply industry is increasing. Regulated water utilities as well as their regulators face challenges in meeting future capital financing needs. In this context, it is important that regulated water utilities and state regulatory commissions pursue and implement effective financing strategies. The failure to obtain adequate as well as timely capital financing may have a detrimental effect on the overall financial viability of a water utility as well as impede compliance with environmental legislation and impede satisfaction of changing water customer needs. There are many ways to finance capital improvements for water utilities. Two especially interesting ones are system availability charges and system development charges.

This report explores the implications for the financing of capital improvements created by recent trends in the water industry. These trends include the increased emphasis on conservation, the emerging potential for competition in the water industry, increased system bypass, privatization, and consolidation or regionalization. There is also an examination of the equity or fairness issues associated with the capital financing of water supply. Several conclusions can be drawn from this research:

! Regulated water utilities should consider exploring and evaluating alternative financing mechanisms, such as availability charges and system development charges, even though there are serious impediments to adopting these financing mechanisms.

- Several recent trends in the water industry, such as system bypass, wholesale competition, and conservation have important implications for the capital financing of water utilities.

- Regulatory commissions can play an important role in addressing the capital financing problems of regulated water utilities; the commission role can involve both regulatory oversight and the ratemaking process.

In brief, regulators can consider alternative financing methods, while at the same time remain vigilant regarding their application.

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FOREWORD

Water utilities face important challenges in meeting future capital financing needs making it essential that regulated water utilities and their commissions pursue and implement effective financing strategies. This report discusses some financing mechanisms for capital improvements, impediments to effective financing of water supply, regulatory strategies for overcoming these financing impediments, and the role of regulatory oversight in capital financing. The report also examines the implications for capital financing created by recent trends in the water industry. This report should be a valuable resource for commissioners and staff in considering financing options for capital improvements for water utilities under their jurisdiction.

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Director
November 1999

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Introduction to Capital Financing

Due to factors that include the needed replacement in many parts of the United States of an aging delivery or distribution infrastructure, compliance with the amended Safe Drinking Water Act, and growing water use associated with economic development and urban growth, the magnitude of required capital improvements in water supply is increasing. Given the increasing costs of capital improvements, many regulated water utilities face challenges in the financing of system expansion.

As observed by Amatetti, both investor-owned and publicly owned water utilities face uncertain times in meeting future capital needs.[1] The financial challenges are a function of the increasing demand for capital financing by water utilities at a time when the flow of capital from conventional sources of capital financing may be decreasing. Under these circumstances, it is important that water utilities and regulators combine efforts in developing and implementing effective capital financing strategies.[2]

The large investor-owned utilities have little difficulty in obtaining financing. In contrast, small investor-owned utilities have more difficulty but can obtain financing if they are creditworthy and are willing to pay the effective financing rates. Given the different sources of financing available, the issue is more one of intergenerational equity (that is, who pays the financing costs) than one of obtaining financing. The small investor-owned utilities can always obtain financing at a particular capital cost or interest rate; very few investor-owned utilities are completely precluded from the capital markets.

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[1] Edward J. Amatetti, *Meeting Future Financing Needs of Water Utilities* (Denver, Colorado: American Water Works Association Research Foundation, 1993).

[2] American Water Works Association, *Water Utility Capital Financing*, Manual M29, Second Edition (Denver, Colorado: American Water Works Association, 1998).

In brief, some regulated utilities face challenges in meeting future capital financing needs. It is important that regulated utilities and their commissions implement effective financing strategies. The failure to obtain adequate capital financing may have a detrimental effect on the overall financial viability of the utility, as well as impede compliance with environmental legislation and satisfying changing water customer needs.

Research Focus

This report begins with an examination of the various risks faced by the water industry as well the risks confronting individual water utilities. The research then reviews:

! Several financing mechanisms for capital improvements,

! Financing mechanisms employed by publicly owned utilities,

! Impediments to effective capital financing of water supply, and

! The role of regulatory commissions and regulatory oversight in capital financing.

The implications for the financing of capital improvements created by recent trends in the water industry are explored. Specifically, these trends are:

! The increased emphasis on conservation,

! The emerging potential for competition,

! Increased system bypass,

! The trend toward privatization, and

! Consolidation or regionalization.

The equity or fairness issues associated with the capital financing of water supply are also addressed.

Water utility capital expenditures are generally classified into three categories: (1) routine replacement of existing plant; (2) routine or normal improvements; and (3) major capital replacements, extensions, and improvements. Since the first two categories are generally financed by utility rate revenues, the focus in this research is on financing major capital investment in water supply.

Water Industry

The water industry in the United States is highly capital intensive, capital intensity being measured by capital investment per customer. There is some evidence that this capital intensiveness may be increasing.[3] The increasing capital intensity ensures that the financing of capital improvements will continue to be an ongoing challenge. For example, the delivery of water requires substantial capital investment in both transmission and distribution facilities.

Water supply facilities tend to have long service lives, which mandates the need for long-term investment planning. In this context, large ("lumpy") increments of capital investment are required at times to replace aging facilities and to take advantage of economies of scale. In addition, a certain amount of capital investment is necessary to provide reliable service. In many cases, due to construction economies it is more cost effective to add large increments of capacity rather than small successive increments to achieve the same result.[4] Since water supply capacity is generally added in large increments, the result can be intermittent periods of capacity underutilization. This underutilization of capacity (presumed to be temporary) can create financial problems for

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[3] Janice A. Beecher, *The Water Industry Compared: Structural, Regulatory, and Strategic Issues for Utilities in a Changing Context.* Report prepared for the National Association of Water Companies, September 1998.

[4] Ibid.

the water utility.[5] In brief, there can be a mismatching of incurred costs and revenue flows resulting in inadequate cost recovery.

For most water utilities, capital costs are increasing in order to satisfy the need for replacing aging system infrastructure, comply with the quality requirements associated with the amended Safe Drinking Water Act, and meet the increasing demands associated with expanding service territories. An important issue in water supply is future capital costs. Given that water is a limited resource, the incremental capital cost as well as the incremental operating cost of new sources of supply is anticipated to increase over time. In the future, the incremental capital cost and incremental operating cost of conventional sources will be compared with the capital and operating costs avoided through conservation and unconventional sources such as water reuse, desalinization, and treated wastewater.

There are several factors that may partially mitigate the future financing challenges of water utilities. Both aggregate demand for municipal water and per capita use are relatively stable. Thus, growth in water demand is generally limited to that associated with expanding service territories. However, this condition exacerbates the cost and scale problems of small water utilities. Another mitigating factor is that, except for small rural systems, most utilities do not provide service to widely dispersed populations.

The important contrasts in capital financing for water utilities are between (1) small and large utilities of all ownership forms, (2) small and large investor-owned utilities, (3) publicly owned and investor-owned utilities, (4) utilities regulated by state commissions and nonregulated utilities [mostly publicly owned or municipally owned, and (5) conventional financing (debt and equity financing) versus nonconventional financing.

It is instructive to note that the capital financing problems in the United States are somewhat unique. In both developed and developing countries, the dominant form of ownership is state-owned or publicly owned water utilities. Privatization in developed countries, except for the United Kingdom, has had little impact on the ownership mix.

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[5] Janice A. Beecher, "PUC 2000: The Water Industry." *NAWC Water* 36 (Summer 1995): 34-43.

Thus, capital financing of water systems in many countries comes from the general revenues of the state. Furthermore, few countries attempt to recover capital costs from water users.[6] In addition, few countries include asset replacement or depreciation expense in the computation of operating costs. The exceptions are Australia and Brazil which recently began to recover a portion of capital costs from users.

In any research on capital financing, it is appropriate to acknowledge the risks associated with the water industry.[7] These risks include business risk, financial risk, and regulatory risk. Conventional wisdom indicates that the water industry has many characteristics which make it less financially risky than investment in other public utility sectors. For example, competition is limited and the service is relatively insensitive to business cycles. The water industry does face substantial regulatory risk from both environmental and rate regulation. In fact, regulatory risk may be the most important risk element, particularly if regulators base policy more on political than on economic considerations. Risks specific to individual water utilities are discussed in the second section of the report.

Report Structure

The second section focuses on two mechanisms for financing capital improvements in water supply, both of recent vintage and which may be viewed as nonconventional for investor-owned utilities. These mechanisms are availability charges and system development charges. There is also a discussion of some financing mechanisms employed by municipally owned or publicly owned utilities and the impediments to effective capital financing as well as specific strategies for overcoming these financing impediments. The section concludes with an examination of the role of the regulatory commission in effective capital financing for jurisdictional water utilities.

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[6] World Bank, *Water Pricing Experiences: An International Perspective*, Technical Paper No. 386 (Washington, D.C.: The World Bank, 1997).

[7] Office of Water Services, *Setting Price Limits for Water and Sewerage Services* (Birmingham, England: Office of Water Services: February 1998).

The third section of the report focuses on specific financing issues in water supply, such as the effects of conservation and competition. Other issues examined include the financing implications of system bypass, regionalization, and privatization as well as fairness issues associated with financing.

The fourth section presents a summary and conclusions. This overview includes a summary of the financing issues and the role of commissions in promoting effective financing for its jurisdictional water utilities; it ends with the conclusions of the research on capital financing.

Throughout the report, there is discussion of the responses of a panel of financing experts to a series of questions regarding capital financing in the water sector. (The panel members are listed in Appendix B.)

Alternative Financing Mechanisms

Risk and Water Utilities

This section discusses the nature of risk for water utilities, two major alternative financing mechanisms, and the role of a state regulatory commission in capital financing choices. Water utilities, like other public utilities, face three general types of risk: business or market, financial, and regulatory risk.[8] Business risk involves the uncertainties resulting from competition and the operation of the market economy. For example, the potential costs associated with complying with environmental and safety regulations as well as the potential loss of wholesale customers via competition can be categorized as business risk.

Financial risk reflects the uncertainties resulting from utility financing as well as those associated with cost behavior and revenue generation. Thus, revenue risk is a subset of financial risk. For example, the costs associated with the capital structure of the

[8] Janice A. Beecher, Patrick C. Mann, and John D. Stanford, *Meeting Water Utility Revenue Requirements: Financing and Ratemaking Alternatives* (Columbus, Ohio: The National Regulatory Research Institute, 1993).

utility as well as the *revenue instability* associated with *conservation pricing* can be categorized as financial risk. Revenue risk, measured for example by the volatility of revenue flows, can also be increased by increased use of commodity rates relative to fixed charges as well as by the implementation of conservation rates.

Regulatory risk involves the uncertainties created by regulatory action. For example, the possible disallowance of operating expenses as well as the possible exclusion of capital expenditures from the ratebase can be categorized as regulatory risk. Thus, regulatory risk is essentially the uncertainty associated with the treatment of costs by regulatory agencies.

A pragmatic way of viewing water utility risk is to examine the elements that constitute or cause risk. These elements include uncertainty and variability.[9] For example, increased uncertainty regarding any aspect of the operations of the water utility, such as its ability to comply with the regulations of the amended Safe Drinking Water Act, means increased perceived risk on the part of both creditors and investors. Similarly, increased variability of water utility revenues (for example, resulting from conservation pricing) or increased variability of supply costs, such as the wholesale cost of purchasing water during drought conditions, means increased perceived risk on the part of creditors and investors. Risk management attempts to minimize the degree of uncertainty and variability in revenues and costs confronting the water utility.

The three types of risk, if perceived to be increasing over time, can translate into higher costs of equity and debt capital for investor-owned water utilities and higher costs of debt capital for publicly owned water utilities.[10] The categories of risk are interrelated. For example, competition in wholesale water markets can increase business and financial risk. In addition, the risk of takeover for both investor-owned and publicly owned utilities is on the increase. This can be viewed as a new form of competition. Financial risk is

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[9] Amatetti, *Meeting Future Financing Needs.*

[10] Beecher, "PUC 2000."

closely aligned with regulatory risk; financial risk can be increased by construction cost inflation and changes in regulatory rules and policies regarding capital expenditures.

Risk is higher for smaller water utilities; risk is also generally higher for water utilities whose common stock is not publicly traded.[11] These two results are not surprising, since utility size and public trading of stock are positively correlated. For example, smaller investor-owned water utilities tend to have higher ratios of equity to total capital and higher costs of capital than larger investor-owned water utilities. A portion of this risk differential between small and large water utilities is a function of the limited market for long-term capital of smaller water utilities. A publicly traded water utility can issue new common stock to achieve balance in its capital structure, that is, reduce its cost of capital. The privately held water utility faces the risk of constrained financing. Water utilities of all sizes face increasing risk from legal proceedings and class action suits, such as those stemming from public health and environmental regulations, or precipitated by the Y2K problem.

The financing options discussed below focus on both financial and regulatory risk. For example, conventional methods of financing such as debt and equity financing generally enhance the ratebase of the investor-owned utility. In contrast, the use of a system development charge may preclude a ratebase increase.

Availability Charges

Dedicated-capacity charges are a relatively new financing method for water utilities. Dedicated-capacity charges have the purpose of recovering costs from customers for capacity constructed primarily for providing service to these specific customers. The availability or readiness-to-serve charge is one type of a dedicated-capacity charge.

The availability charge is a charge designed to recover the costs incurred by a water utility in constructing facilities primarily for the benefit of new or future customers. The availability charge is imposed between the time that service is made available to the

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[11] Thomas W. Zepp, "Water Utilities and Risk," *NAWC Water* 40 (Winter 1999): 12-13.

future customer and the time that actual water service is initiated. The availability charge may be based on lot frontage or similar bases. When water service is actually initiated, the availability charge is terminated.

The availability charge may be particularly appropriate in cases where a new housing development is created and the water utility constructs facilities for that development. The initial system costs may exceed the level that can be realistically recovered from the low initial customer base. Thus, it can be argued that it is appropriate that lot owners be charged for having service available, even though at that time they are not actually receiving service. The availability charge is essentially an access charge reflecting the cost of providing consumer access to the water system. Access charges are payments for system access regardless of usage and should recover only the usage-insensitive costs incurred when consumers join the system. The justification for the availability charge is that the water utility incurs certain costs regardless of whether or not consumers receive service.

An advantage of the availability charge is that it promotes cost sharing between existing customers and unconnected property owners who eventually derive benefits from the facilities of the water utility. It adheres to the standard of cost-causation where the water utility has incurred significant capital investment to provide service to both existing and future customers. A problem associated with availability charges that is common to both publicly owned and investor-owned utilities is that of remedies for nonpayment.[12] Since the customer who is being assessed the charge is not connected to the system, termination of service is not an appropriate response to nonpayment. Investor-owned utilities may not have the level of enforcement powers that publicly owned utilities have, thus reducing the attractiveness of availability charges for investor-owned utilities. Other disadvantages of availability charges are discussed below under impediments to capital financing.

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[12] American Water Works Association, *Water Rates and Related Charges*, Manual M26, Second Edition (Denver, Colorado: American Water Works Association, 1996).

System Development Charges

Periodically, water utilities incur capital expenditures for system improvements. Regulators must decide which capital costs are more appropriately recovered by increased commodity rates and which are more appropriately recovered by fixed charges. If the capital investment is oriented toward serving demand growth caused by the addition of new customers rather than toward benefitting existing customers, it is inefficient to recover these capital costs from existing customers. An appropriate financing option is the front-end capital payment or capital contribution, that is, a payment by new customers to recover the capital investment required to provide service to the new customers. The rationale for the front-end charge is to require new customers to finance system improvements that directly benefit them and are largely a result of demand growth caused by the new customers.

One type of front-end charge is the system development charge. This is a one-time charge to new customers when they are connected to the water system. These charges are also known as system capacity charges, impact fees, system buy-in charges, and facilities charges. Generally, these charges are paid by the developer at the time the new customer connects to the water system. The developer in turn passes the expenditure onto the purchaser or the new customer through the cost of the new home.[13] As a result, many developers and home builders' associations have opposed system development charges, since they initially pay the charge which adds to the cost of housing construction.[14]

If used, the system development charge should be limited to recovering capital expenditures for new distribution facilities required by the projected demands of new customers; the system development charge is not appropriate for recovering operating costs. A system development charge ensures that rates for existing customers need not be increased to recover the costs of facilities that have been constructed for new

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[13] Jerome B. Gilbert, "EBMUD's System Capacity Charge," *Capital Financing* (Denver, Colorado: American Water Works Association, June 1990), 33-46.

[14] David B. LaFrance, "Growth and Conservation: Should the HBA Pay its Way," *Proceedings of CONSERV99* (Monterey, California: February 1999).

customers. In fact, system development charges can even have the effect of lowering rates if they are a significant source of front-end capital.

The merits of the system development charge are several. First, the system development charge can preclude existing customers from having to subsidize the new customers. Second, by requiring the customers who have caused the system growth to pay for that growth, the system development charge can allow the water utility to maintain a common rate schedule for both existing and new customers, which avoids the implementation of vintage rates that distinguish between old and new customers. Third, the system development charge reduces the need for rate increases to accommodate system growth.

The system development charge is an option for financing small investor-owned water utilities if economic growth is driving system costs. However, many investor-owned water utilities will reject this financing option since the charge does not increase its ratebase and earnings potential. In sum, system development charges are treated similar to capital contributions-in-aid-of-construction (CIAC). Contributed plant is normally excluded from the ratebase of the utility. Thus, neither earnings nor depreciation are allowed on the contributed plant. There are subtle differences between CIAC and system development charges since the latter may include elements that are not equivalent to CIAC, and thus regulators need to consider the possible inclusion of these elements in the ratebase of the investor-owned utility. That is, the system development charge can be used to recover more than the cost of connection and hookup usually covered by CIAC.

At one time, there were tax considerations that made the system development charge somewhat undesirable for investor-owned water utilities.[15] For example, the 1986 Tax Reform Act made capital contributions taxable as income. This part of the tax code

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[15] Fred P. Griffith, "System Development Charges: Ten Questions," *Capital Financing* (Denver, Colorado: American Water Works Association, June 1990), 47-50.

was repealed in 1996. In brief, the ratebase effect of system development charges reduces the attractiveness of this financing mechanism for investor-owned utilities.[16]

Capital Financing in the Public Sector

Publicly owned utilities have greater access to public funding sources than do privately owned utilities. An example is the drinking water state revolving funds created by the 1996 amendments to the Safe Drinking Water Act. As Borrows and Simpson indicate, some states do not permit investor-owned utilities to have access to the state revolving funds while other states limit the amount of funds that can be used by privately owned utilities.[17] This, along with other government bond type funding options, allows publicly owned utilities to have lower overall cost of capital than privately owned utilities.

There are several recent capital financing trends in the publicly owned sector. One trend is the increasing reliance on builders and developers to provide revenue to support water system expansion. These revenues come from contributions, impact fees, system capacity charges, and system development charges. System development charges are becoming relatively common.[18] Another trend is the increased reliance on conservation and demand management programs to reduce and/or postpone the need for system expansion and the need for capital financing.[19] A third trend is the increased use of special purpose surcharges to finance both utility operations and routine replacements.

The author asked a panel of experts on water utility financing (see Appendix B), "What financing trends or innovations are emerging in the publicly owned sector that may be transferable to the investor-owned sector?" The panel responses were varied, as

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[16] American Water Works Association, *Water Rates and Related Charges.*

[17] John D. Borrows and Todd Simpson, *The Drinking Water State Revolving Loan Fund: A Guide for Regulatory Commissions* (Columbus, Ohio: The National Regulatory Research Institute, 1997).

[18] LaFrance, "Growth and Conservation."

[19] United States Environmental Protection Agency, *Water Conservation Plan Guidelines* (Washington, D.C.: Environmental Protection Agency, 1998).

shown in Table 1. More use of long-term debt, interim financing and lease financing were among the options mentioned. One panel member noted that the primary financing trend in the publicly owned sector is public-private partnerships of varying types while the primary financing trend in the privately owned sector is consolidation. That is, large investor-owned utilities are acquiring both investor-owned and municipally owned utilities.

TABLE 1

WHAT FINANCING TRENDS OR INNOVATIONS ARE EMERGING IN THE PUBLICLY OWNED SECTOR THAT MAY BE TRANSFERABLE TO THE INVESTOR-OWNED SECTOR?

!	Increasing reliance on long-term debt which allows financing costs to more closely match the investment benefit stream.
!	Use of more long-term debt to replace equity financing since some privately owned utilities are under debt capitalized.
!	Increased flexibility in the use of short-term debt which allows utilities to reduce risk.
!	Use of rate stabilization and capital reserve funds where large future capital requirements are projected, which increases bond ratings and lowers the cost of capital.
!	Increased use of lease financing.
!	Use of short-term interim financing, which in some cases defers interest payment until the issuance of long-term financing.
!	Funding of a portion of infrastructure replacement from current revenues, similar to publicly owned utilities, as opposed to conventional equity and debt financing, thus saving dividend and interest costs.
!	Use of special surcharges, for example, a distribution improvement charge, to finance capital improvements.

Source: Panel of Financing Experts.

Impediments to Capital Financing

The rationale for the availability charge is substantially reduced in cases where a developer has provided (contributed) the distribution system infrastructure. In some cases, the availability charge may not have a rational costing basis. For example, the availability charge could include usage-sensitive costs such as operating costs that are unrelated to the potential connection of the new customer. In addition, regulators and consumers may strongly question the fairness of a charge for service not actually being rendered. Finally, there is the problem of establishing a mechanism for forcing the property owner to pay the availability charge. For example, it is difficult to identify future customers, who may not be determined until the lot is sold and/or service is initiated. For these reasons, the availability charge has had limited implementation in the water industry.

There are also problems associated with system development charges. First, in relying on the charge to satisfy current revenue requirements, there is the potential for revenue instability since these front-end charges are tied to system growth which will fluctuate depending upon both local and national economic conditions. Second, system development charges can be inefficient by having a noncost basis, perhaps being set equal to charges in adjacent communities. A cost-based system development charge should be based on the unit cost of capacity incurred by the utility and the amount of capacity demanded by new customers. While relatively simple in concept, the system development charge is somewhat complicated in its determination.[20]

Third, the system development charge is more controversial when used to recover the cost of new facilities jointly used by new and existing customers; it is more appropriate to limit the charge to recovering the cost of facilities constructed for the exclusive benefit of new customers. The system development charge in its varying forms has been more widely implemented in the water industry than has the availability charge. For example, Denver Water has recently implemented a new set of system development charges for residential customers that are based on property or lot size. Thus, these charges tend to

[20] LaFrance, "Growth and Conservation."

reflect the concept of value-of-service pricing. The Denver charge includes a fixed fee based on the cost of capacity necessary for domestic or indoor usage, plus a charge per square foot of the lot for outdoor usage. Finally, as indicated above, the system development charge has been implemented widely among publicly owned utilities, but not among investor-owned utilities, given its lack of contribution to ratebase.

The Role of Regulatory Commissions

Public utility regulation can affect capital financing choices both directly and indirectly. Regulatory lag associated with the rate setting process can destabilize revenue and increase the financial risk for water utilities. Thus, expedited rate proceedings and a preapproval process for capital expenditures are some potential ways for regulators to lower financial and regulatory risk. For example, investor-owned utilities may be reluctant to incur costs for conservation and demand-side management programs if there is uncertainty as to whether these capital expenditures are recoverable, either by inclusion as operating costs or in the ratebase. Expenditure preapproval decreases this uncertainty and the financial risk associated with these capital expenditures.

The use of availability charges and system development charges in financing capital improvements in water supply exemplifies the notion that capital financing cannot be separated from rate design in the regulatory process. These special charges, given their particular design, can have numerous effects including those on *capital requirements* and system expansion.

The appropriate role of a regulatory commission if it wishes to allow availability charges is relatively simple: The commission needs to ensure that the availability charge has a logical costing basis. For example, the commission needs to ensure that the availability charge does not include operating costs that are unrelated to the potential connection of new customers. The commission needs to ensure that the availability charge is not recovering costs that are being recovered by other charges or by commodity rates. In addition, regulators need to assist in the education of consumers, many of whom may question the fairness of a charge for service not actually being rendered. Finally, the commission needs to assist the water utility in establishing a mechanism for inducing the property owner to pay the availability charge.

The appropriate role of regulatory commissions if it wishes to allow system development charges is more complex. First, the commission needs to address the potential for revenue instability since these front-end charges are tied to system growth, and this growth will fluctuate depending upon economic conditions. Second, the commission needs to ensure that the system development charges have a logical or rational cost basis. Third, system development charges may discourage system growth in some cases, for example where they create rate shock for the new customers, and thus preclude the cost savings to the water utility and all of its customers flowing from economies of scale.

Fourth, the commission needs to ensure that system development charges recover only the cost of facilities constructed for the exclusive benefit of new customers and not the cost of new facilities jointly used by new and existing customers. That is, the commission needs to ensure that system development charges recover the capital costs from the beneficiaries of the service and that the charges appropriately allocate the cost of facilities between new and existing customers. Raftelis suggests other criteria that need to be addressed by the commission regarding system development.[21] These criteria are implementation, for example, the cost and consumer reaction, and simplicity, which includes ease of understanding, ease of explanation, ease of future adjustments, and the potential for litigation. Finally, the commission needs to examine and develop incentive mechanisms to induce investor-owned utilities to employ system development charges as a financing option. The necessary incentives could include a gradual phasing out of the ratebase reduction or an increased rate of return on ratebase.

The author asked the panel of capital financing experts the question, "How can availability charges and system development charges be made attractive financing options for investor-owned water utilities?" They had many suggestions (Table 2).

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[21] George A. Raftelis, *A Comprehensive Guide to Water and Wastewater Finance and Pricing* (Chelsea, Michigan: Lewis Publishing, 1993).

TABLE 2

HOW CAN AVAILABILITY CHARGES AND SYSTEM DEVELOPMENT CHARGES BE MADE ATTRACTIVE FINANCING OPTIONS FOR INVESTOR-OWNED WATER UTILITIES?

! Regulatory policies that reduce regulatory uncertainty.

! Regulatory policies that allow depreciation on contributed capital or front-end charges.

! Regulatory recognition that the utility incurs some costs in providing a “readiness to serve” and thus should recover these costs.

! Regulatory policies that allow ratebase treatment of the capital recovery revenues since the alternative is to recover these capital costs by including the costs in operating costs and recovering them from all ratepayers over time.

! It may be impossible to make these front-end charges more attractive since regulatory commissions view the revenues as contributed capital and thus exclude them from ratebase.

! The charges may not be in the best interest of the investor-owned utility since risk is reduced; that is, consumers are paying for infrastructure upfront, so one can argue that rate of return should be reduced.

! There are too many obstacles to the use of these charges for investor-owned utilities including shifting risk from investors to customers.

! The regulatory problem is that the availability charge involves forced payment for the privilege of owning property absent services being rendered.

! The regulatory problem with availability charges is the trouble that utilities have in collecting the charges.

! System development charges are only viable in service areas experiencing substantial economic growth; system development charges will not be attractive to investor-owned utilities experiencing little growth in their service area.

! In the long-term, debt and equity financing are superior options to both availability and system development charges since they enhance the ratebase and provide better earnings and cash flow potential.

! An important benefit of these charges for small utilities is enhanced cash flow; this benefit may offset, at least in the short-term, the negative effects.

Source: Panel of Financing Experts.

Raftelis identifies criteria that regulatory commissions can employ in evaluating availability charges, system development charges, and other related financing mechanisms.[22] These include fairness, revenue potential, ease of implementation, and simplicity:

- Does the charge or fee recover cost fairly from the beneficiaries of the service?
- Does the charge generate sufficient revenues to satisfy capital requirements?
- Is the charge relatively easy to implement?
- Is the charge relatively easy to explain and modify in the future?
- Does the implementation of the charge negatively impact growth?
- Does the water utility have an incentive to employ the financing option?

The assessment of the appropriateness of the charges will involve tradeoffs among the several criteria.

Regarding the financing of small investor-owned water utilities, the regulatory commission can be proactive in encouraging financial institutions to establish what are termed water trusts.[23] The water trust is designed as a loan pool for small investor-owned utilities. The trust can provide the small utility with medium-term and long-term debt capital. In this context, the regulatory commission has the responsibility of ensuring that the debt financing does not translate into substantial rate increases to cover the debt financing costs.

[22] Ibid.

[23] Sumner B. Miller and Paul R. McCrary, "The Water Trust: Long Term Debt Financing for Small Water Companies," *Proceedings of the Ninth NARUC Biennial Regulatory Information Conference,* Volume III (Columbus, Ohio: The National Regulatory Research Institute, September 1994), 3-14.

The Missouri Public Service Commission has been proactive in the area of capital financing of small water utilities. The Missouri PSC was instrumental in developing legislation which created a revolving loan program for small investor-owned water and sewer utilities.[24] The loans are limited to small investor-owned utilities with less than 500 customers, are limited to a maximum of $80,000, and must be repaid within five years. Although another state agency is responsible for approving and administering the medium-term loans, the Missouri PSC is responsible for reviewing the loan applications as well as reviewing the financial viability of the participating utilities.

The capacity of a water utility to obtain financing for capital projects requires it to establish creditworthiness regarding capital markets. Establishing and managing creditworthiness is linked to managing risk.[25] Via capacity management the commission can and should be a major player in the minimization of risk for water utilities under its jurisdiction.[26]

Selecting the appropriate financing mechanism for a water utility can be a complicated and comprehensive process. It may be necessary for the commission to seek input not only from the water utility but also from utility customers and financial professionals. This input can be valuable in considering the tradeoffs between financial and nonfinancial factors associated with financing options.

General Trends and Policies Affecting Capital Financing

[24] William L. Sankpill, "Innovative Financing for Water and Sewer Companies," *Proceedings of the Eighth NARUC Biennial Regulatory Information Conference*, Volume IV (Columbus, Ohio: The National Regulatory Research Institute, September 1992), 121-125.

[25] Edward J. Amatetti, "Managing the Financial Condition of a Utility," *American Water Works Association Journal* 86 (April 1994): 176-187.

[26] John D. Wilhelm, *Water Capacity Development and Planning: A Benchmark Guide for Regulatory Commissions* (Columbus, Ohio: The National Regulatory Research Institute, 1999).

Several trends in the water industry have important implications for the financing of capital expenditures. These include the increasing emphasis on conservation, the increasing potential for wholesale competition, the increasing potential for both system bypass and water reuse, the trend toward regionalization, and the continuing trend of privatization. These trends have mixed implications for the financing of water utility facilities. For example, conservation may have a negative impact on financing in the short term but a positive impact in the long term.

Conservation and Financing

Conservation rates affect revenue stability for the water utility and thus its capability of acquiring financing. Conservation water rates have the most substantial impact on more discretionary water usage such as outdoor water consumption. As a result, water revenues are somewhat dependent on weather patterns.[27] An important point is that water utilities and their regulators need to develop coping strategies to manage the risk of revenue volatility and instability associated with some forms of conservation pricing. However, one could argue that conservation pricing and other conservation strategies reduce revenue volatility in the long-term, with the exception of occasional droughts.

Changes in demand patterns cause revenue variability and affect the cost and feasibility of financing options. The degree of revenue volatility is partly a result of rate design. For example, the increasing-block rate structure often adopted as a conservation tool amplifies revenue variability. In contrast, the traditional declining-block rate schedule tends to decrease revenue variability. While conservation rates can postpone or even permanently preclude expensive expansion of system facilities, a positive long-term financing effect of conservation, it is suggested that regulators examine the revenue volatility aspect of conservation rates. Revenue instability causes increased borrowing costs, more complicated long-term system planning, as well as political and regulatory

[27] Washington State Department of Health, *Overview of Conservation-Oriented Rate Structures for Public Water Systems* (Olympia, Washington, Washington State Department of Health, April 1995).

problems. If the volatility dimension is not addressed, the financing prospects for the utility can be harmed and the financial risk confronting the water utility can be increased.

Several managerial strategies have been suggested regarding the revenue instability induced by conservation rates.[28] The coping strategies include more frequent rate adjustments, the creation of a contingency (rate stabilization) fund, the inclusion of a safety margin in the determination of revenue requirements, and the development of an automatic rate adjustment mechanism. The key to the success of these coping strategies is the quantification of the short-term and long-term effects of the conservation rate structure. Quantification includes the simulation of revenues under different climatic conditions. The quantification of the revenue volatility associated with a conservation rate structure can be the basis for making more frequent rate adjustments, the creation of a contingency or reserve fund, the inclusion of a risk margin in revenue requirements, and the development of an automatic rate adjustment mechanism.

Again, conservation activities can enhance revenue stability in the long term by making usage less sensitive to weather patterns. At the same time, conservation activities reduce the risk associated with underutilized system capacity.

In brief, the risk of revenue instability increases with the implementation of conservation rates, at least in the short term. However, improved planning and better rate design can decrease the magnitude of revenue instability.[29] In addition, the possible mismatch of costs and revenues can be addressed via rate adjustment mechanisms and the development of contingency funds.

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[28] Thomas W. Chestnutt, Casey McSpadden, and John Christianson, "Revenue Instability Induced by Conservation Rates," *American Water Works Association Journal* 88 (January 1996): 52-63.

[29] Thomas W. Chestnutt, Janice A. Beecher, Patrick C. Mann, et al., *Designing, Evaluating, and Implementing Conservation Rate Structures.* Handbook sponsored by the California Urban Water Conservation Council, July 1997.

A 1994 survey of state commissions found that few commissions had implemented methods to address the impact of water conservation activities on revenue stability.[30] This is perplexing since a number of commissions had initiated measures for dealing with the revenue consequences of energy conservation. The revenue stability measures implemented for water utilities include special charges, phase-in plans, adjustments in subsequent rate cases, rate stabilization reserves, and automatic annual surcharges.

Competition and Financing

Any increase in competition, even of the limited variety such as wholesale competition, increases uncertainty and thus increases the financial risk facing the regulated water utility. This increase in financial risk can preclude some financing options for the regulated utility and increase the cost of others.

For example, assume the following scenario for a small investor-owned water utility. The water utility serves a mixture of residential and commercial users, and one large industrial user constituting 25 percent of total usage. This large user contracts to be supplied by a nearby municipally owned water utility which agrees to finance the pipeline necessary to provide service to this large user. This switch in supply sources will have a devastating financial effect on the regulated water utility. Even if the investor-owned water utility is successful in retaining the large user, for example by reducing its rates, the long-term effect is increased uncertainty and increased financial risk for the regulated water utility. Furthermore, the rate reduction for the large user can translate into higher rates for the commercial and residential users. The rate increase effect on usage, that is, the existence of price elasticity of demand, is another factor which increases uncertainty and financial risk for the regulated water utility.

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[30] Janice A. Beecher, Patrick C. Mann, Youssef Hegazy, and John D. Stanford, *Revenue Effects of Water Conservation and Conservation Pricing: Issues and Practices* (Columbus, Ohio: The National Regulatory Research Institute, 1994).

Obviously, at the distribution or delivery level, competition in water supply is highly impractical. However, competition in the water industry is emerging in numerous forms.[31] One form involves investor-owned water utilities competing with each other to provide support services to publicly owned water agencies . A second involves direct competition between water utilities seeking to acquire other water utilities, both investor-owned and publicly owned, or seeking to serve new residential and business developments adjacent to their existing service area. A third form involves competition between water utilities regulated by state commissions and nonregulated (mostly publicly owned) water utilities to provide water service to a region. The competition in service contracting, the territorial competition, and the broader competition of privately owned versus publicly owned utilities increases uncertainty and thus increases the financial and regulatory risks confronting regulated utilities.

System Bypass and Financing

System bypass has financial effects similar to that of competition and conservation. Any system bypass, even partial, increases uncertainty and thus increases the financial risk facing the jurisdictional water utility. This increase in financial risk can preclude some financing options for the regulated water utility and increase the cost of other financing options.

For example, assume this scenario for a small investor-owned water utility. Again, the water utility serves a mixture of residential, commercial, and one large industrial user constituting 25 percent of total usage. This large user either opts to resort to self-supply for its industrial use (for example, cooling usage) or implements a series of conservation measures such as recirculation or re-use processes. The effect is a reduction in usage of 50 percent. This bypass or conservation activity has a substantial financial effect on the regulated water utility. Even if the investor-owned water utility is successful in maintaining

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[31] Henry M. Duque, "Competition in the Water and Wastewater Industries," *NAWC Water* 38 (Fall 1997): 17-20.

revenues, perhaps by increasing the rates for the residential and commercial users, the long-term effect is increased uncertainty and financial risk for the regulated water utility. Furthermore, the higher rates for the other users, given the price elasticity effect, is another factor which increases uncertainty and financial risk for the regulated water utility.

Regionalization and Financing

Regionalization and/or consolidation constitutes an important change in the manner that water services are provided. In addition to the potential efficiencies in both operation and capacity planning, regionalization has important implications for the financing of capital expenditures. Regionalization mitigates some of the financing obstacles for water utilities. For example, more financing options are available to the larger consolidated water utility than are generally available to the several smaller water utilities prior to consolidation. Regionalization, consolidation, or merger/acquisition can be the solution to the problem of small water systems in financing capital investment to replace aging infrastructure, comply with the amended Safe Drinking Water Act, or facilitate the development of regional water supplies.

More specifically, regionalization allows capital to be diverted or freed up in small water systems. This capital can than be deployed to improve delivery system infrastructure.[32] Similarly, regionalization can free up the bonding capacity of small municipalities. Regionalization can make small, financially nonviable water utilities into viable water firms. In brief, regionalization can solve, in part, the nonviability problem for small water systems as well as improve operational efficiency and compliance with environmental regulations.[33]

Privatization and Financing

[32] William L. Sankpill and James A. Merciel, "Regionalization/Consolidation of Water Systems in Missouri," *NAWC Water* 36 (Spring 1995): 22-23.

[33] Janice A. Beecher, *The Regionalization of Water Utilities* (Columbus, Ohio: The National Regulatory Research Institute, 1996).

Privatization involves private ownership and/or operation of facilities for providing public services. Traditionally, under a privatization arrangement, publicly owned water and wastewater utilities have turned to the private sector to attain cost-effective delivery of service.[34]

There are several financing aspects to privatization. One approach is the traditional agreement in which the private firm is involved in all aspects of facility operation. The private firm designs, constructs, and operates the water facility and then sells the water to the publicly owned (or investor-owned) utility at a negotiated wholesale rate. An alternative approach is a sale with an operating contract in which the water utility sells a previously constructed facility to the private firm, which then operates the facility much as if there is a full-service agreement.

There are many advantages to privatization. The primary ones in the context of this research are the savings in construction and operating costs, increased operational efficiency, and reduced risk in construction and operation for either the publicly owned water utility or the small investor-owned water utility.

For example, the various forms of privatization can be applied to both publicly owned and privately owned water utilities.[35] Each form of privatization can have positive effects on financing costs and risks facing the individual water utility. The water utility can be acquired outright by a private firm. The water utility can permit the private firm to construct and operate system facilities (e.g., treatment plant). Or the water utility can select a private firm to provide operating and other support services (operational outsourcing). However, privatization by operating contract does not necessarily bring capital to satisfy the financial needs of the water utility. That is, privatization via contracts may improve efficiency but does not help obtain private sector financing. In this context, privatization can mean competition for capital via different solutions for future supply. For example, it

[34] Amy Shanker and Len Rodman, "Public-Private Partnerships," *American Water Works Association Journal* 88 (April 1996): 102-107.

[35] Robert W. Poole, "Privatization and Public Utilities," *NAWC Water* 36 (Winter 1995): 26-33.

provides the small privately owned utility with a choice among building a facility, and possibly having another private firm operate it; having the private firm both build and operate the facility; or purchasing capacity or water from another utility.

In sum, privatization or outsourcing can be a means by which a public agency or an investor-owned utility solves its financing problems. However, there are some impediments to the privatization of water supply facilities in the United States. Privatizers generally do not desire to be subjected to rate regulation. Thus, privatization agreements are often structured so that the privatizer is outside the jurisdiction of the regulatory commission.

To avoid this conflict, a commission could encourage larger investor-owned utilities under their jurisdiction, instead of nonjurisdictional private firms, to engage in privatization regarding the smaller investor-owned water utilities in their jurisdiction. Most of the larger investor-owned water utilities in the United States are actively engaging in both privatization and regionalization activities primarily via the acquisition of water systems of both ownership types.[36]

According to some, a counterpart to privatization can also be a financing strategy, particularly for small investor-owned water utilities having difficulty obtaining access to the capital markets. This counterpart is the conversion of investor-owned water utilities to public water authorities or the acquisition of investor-owned water utilities by municipally owned or publicly owned water utilities. Given the issuance of additional Safe Drinking Water Act regulations, this somewhat controversial form of capital financing may prove to be more salient in the future.

The acquisition of investor-owned utilities by municipally owned utilities generally involves fewer complications than the transferring of assets of investor-owned utilities to a newly formed public water district or water authority. However, it is questionable whether a commission can play a major role in influencing either the terms of the acquisition or the organization of the water authority.

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[36] Janice A. Beecher, G. Richard Dreese, and John D. Stanford, *Regulatory Implications of Water and Wastewater Utility Privatization* (Columbus, Ohio: The National Regulatory Research Institute, 1995).

As a last resort, the regulated water utility could utilize a nonconventional financing option such as lease financing. Lease financing can be a viable option if the investor-owned water utility seeks to limit its long-term debt as well as prevent the dilution of its common stock. That is, when the issuance of additional debt or equity is viewed as undesirable, leasing and similar financing techniques emerge as alternative capital financing mechanisms.

The author asked the panel of financing experts the question: "Are public-private and private-private partnerships a realistic solution to the financing problems of small investor-owned water utilities? The panel responses are reported in Table 3. One panelist suggested that utilities of all ownership types might well examine the various

TABLE 3

ARE PUBLIC-PRIVATE AND PRIVATE-PRIVATE PARTNERSHIPS A REALISTIC SOLUTION TO THE FINANCING PROBLEMS OF SMALL INVESTOR-OWNED WATER UTILITIES?

! Changing system costs are making some small utilities uneconomic entities.

! Any large utility, public or private, which could take over a smaller utility and achieve economies of scale would produce a beneficial result.

! There are numerous cases where private-private "teaming arrangements" have been employed successfully to complete specific projects.

! The trend in the United States is the municipal acquisition of investor-owned utilities rather than the private acquisition of investor-owned utilities.

! There are numerous opportunities for both public-private and private-private collaboration; examples include joint facilities, privatization, outsourcing, and joint metering and billing.

! Utilities of all ownership types need to examine the various forms of collaboration that could reduce average unit costs.

! The large private utility is more interested in ownership than in debt financing and many small utilities would be wary of other privately owned utilities as a financing partner, due to the fear of acquisition.

Source: Panel of Financing Experts.

forms of public-private collaboration that could reduce average unit costs. Others also emphasized these opportunities. Finally, one panel member noted that private-private partnerships make sense in only a limited set of cases since in their opinion acquisition is a preferable approach to the financing problems of small water utilities.

Efficiency Versus Equity in Financing

As in rate regulation, the concept of fairness in capital financing cannot be analyzed in isolation from the concept of efficiency. For example, the pursuit of efficiency in utility regulation can produce actions that are viewed by the public as unfair or inequitable. As Zajac indicated, economic efficiency does not necessarily conform to intuitive notions of fairness and equity; as a result, he argues that economic efficiency should be viewed as a necessary but not a sufficient condition for fairness.[37]

The difficulty in having a meaningful debate over the question of fairness in utility regulation lies in the multiple perceptions of fairness and unfairness.[38] Some consumers may feel that it is unfair to have to pay for services such as water. Other consumers may feel utilities should not receive a profit (including the cost of capital) from providing essential utility services. Other consumers may believe that it is unfair to be charged for service not yet received such as through an availability charge. Retirees may think it is unfair to expand the water system to accommodate commercial development. The different perceptions of fairness associated with the different stakeholders in the regulatory process forces regulators to engage in a delicate balancing act in utility rate-setting and capital financing.

Although somewhat intertwined, equity and efficiency are separable. That is, efficient financing schemes such as availability and system development charges may be perceived by many consumers as unfair. However, with regulatory commission input, it is

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[37] Edward E. Zajac, *Political Economy of Fairness*, (Cambridge, Massachusetts: MIT Press, 1995).

[38] Janice A. Beecher and Patrick C. Mann, "Equity, Fairness, and Conservation Rates," *CONSERV99 Proceedings* (Monterey, California: February 1999).

possible to design financing mechanisms that satisfy both fairness and efficiency criteria. For example, the capital financing mechanism employed by the water utility must assure in general that each generation of customers pays for facilities that they require and does not pay for facilities required by other generations of customers.[39] That is, the financing plan must satisfy intergenerational equity standards by matching the cost impact on consumers with the benefits received by these consumers. Financing options must be subjected to the criterion of achieving intergenerational equity.

The system development charge is an example of a financing mechanism that satisfies both efficiency and equity criteria. The system development charge adheres to the cost-causation standard by requiring new customers to finance system improvements that directly benefit the new customers and that are a result of the demand caused by the new customers. In addition, system development charges are equitable because they avoid bond financing of the expansion facilities. If conventional debt financing was used to finance the full cost of expansion, debt service cost recovery would result in rate increases; thus existing customers would be subsidizing demand growth.[40]

Summary and Conclusions

Many regulated water utilities face the challenges of capital financing. It is important that regulated water utilities and their commissions implement effective financing strategies. The failure of regulated utilities to obtain capital financing in a timely manner will have a detrimental effect on their financial viability.

The water industry in the United States is highly capital intensive. This insures that the financing of capital improvements will continue to be a problem in the future. In addition, water supply facilities tend to have long service lives, which mandates the need for long-term capacity planning. In this context, large, "lumpy" increments of

[39] Raftelis, *A Comprehensive Guide.*

[40] Ibid.

capital investment are required to replace aging facilities, take advantage of economies of scale, and provide reliable water service. The result can be intermittent periods of capacity underutilization. This underutilization of capacity can create financial problems for the water utility, primarily via inadequate cost recovery.

An important issue in water supply is future capital costs. Given that water is a limited resource, the incremental capital and operating costs of new supply sources is anticipated to increase over time. Regulators and their jurisdictional utilities are advised to compare the incremental costs of conventional sources with the incremental costs to be avoided under both conservation and water re-use. Regulators and their jurisdictional utilities will also want to compare the incremental costs of conventional supply sources with the incremental costs of desalinization and treated wastewater facilities.

Regulatory Oversight

As indicated by Kaloko, regulatory commissions must assume an important role in addressing the financing problems of jurisdictional water utilities.[41] The regulatory environment, which includes both the policies and practices of commissions and the perceptions of the participants in the capital markets, can affect the scope of financing alternatives and the level of financing costs for regulated water utilities. The regulatory solutions to the financial problems of jurisdictional water utilities involve both regulatory oversight and the ratesetting process.

There are several regulatory oversight strategies appropriate for mitigating capital financing problems. First, commissions can encourage and assist in the consolidation of water utilities, as well as promote their acquisition by both investor-owned and publicly owned utilities. Second, commissions can assist in establishing mechanisms such as water trusts for infusing capital into the regulated utilities. Third, commissions can have regulated utilities evaluate alternative sources of supply, including interconnection with

[41] Ahmed Kaloko, "The Financial Challenge for Water Utilities," *Proceedings of the Ninth NARUC Biennial Regulatory Information Conference*, Volume III (Columbus, Ohio: The National Regulatory Research Institute, September 1994), 33-48.

other water utilities. Finally, commissions can develop and implement alternative financing mechanisms, such as availability charges and system development charges.

Regarding rate regulation, there are several regulatory strategies appropriate for mitigating the capital financing problems. Commissions can continue the process of simplifying rate fillings for small utilities. They can consider shorter depreciation periods for water plant investment. Commissions can develop incentive mechanisms for adopting alternative financing mechanisms by jurisdictional utilities. They can approve fees and surcharges, such as an infrastructure replacement surcharge which replaces conventional debt and equity financing.

Finally, commissions can be proactive in analyzing or evaluating financing options. The analyses by commissions can indicate the consequences of the options and clarify the associated tradeoffs. The commission analyses can be both qualitative and quantitative. That is, the evaluation methods can vary from highly quantitative to highly qualitative, or somewhere in between. The benefits of commission evaluations of financing options include improved decision-making, decreased financial risk and uncertainty, and the avoidance of unanticipated outcomes.

Several criteria used for evaluating rate design can possibly be applied to evaluating capital financing alternatives.[42] The criteria include:

- How well does the financing mechanism promote resource efficiency?
- How well does the financing mechanism promote cost efficiency?
- How well does the financing mechanism assure financial viability?
- How well does the financing mechanism provide revenue stability?
- How understandable is the financing mechanism to the various stakeholders?

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[42] Beecher, Mann, and Stanford, *Meeting Water Utility Revenue Requirements.*

! How well does the financing mechanism minimize intergenerational inequities?

! How difficult is it to implement the financing mechanism?

These criteria can assist commissions in evaluating and choosing among financing alternatives.

Again, the ability of the regulated water utility to acquire the necessary financing of capital facilities is a function of its ability to convince the capital markets of its creditworthiness. This requires that utility managers be more cognizant of the factors that affect financial performance and risk, for example, drinking water regulations, unstable revenues, and rate shock. Commissions obviously can play a major role in assisting the utility in managing risk and improving financial performance.

The author asked the panel of financing experts a final question: "What are the most important policies that a regulatory commission could implement to assist small investor-owned water utilities in obtaining capital financing?" See Table 4 for the responses. The main theme implicit in the comments is that regulators should provide a more flexible rate regulatory process in which the conventional adversarial atmosphere is replaced by a more cooperative partnership environment.

Conclusions

There are several conclusions that can be drawn from this analysis of the capital financing of water supply.

! Investor-owned utilities need to explore and evaluate financing mechanisms such as availability charges and system development charges, even though there are impediments to adopting these alternative financing mechanisms. The regulated utilities must be able to justify the alternative approaches to capital financing.

! Several recent trends in the water industry including system bypass, wholesale competition, and conservation have important implications for the capital financing of water utilities. These trends present challenges to water utilities seeking capital financing.

- Regulatory commissions can play an important role in addressing the capital financing problems of jurisdictional water utilities. The commission role can involve both regulatory oversight and the ratemaking process.

TABLE 4

WHAT ARE THE MOST IMPORTANT POLICIES A REGULATORY COMMISSION COULD IMPLEMENT TO ASSIST SMALL INVESTOR-OWNED WATER UTILITIES IN OBTAINING CAPITAL FINANCING?

!	The regulatory commission should promote debt or capital pooling so that small water utilities can gain access to the capital markets.
!	The regulatory commission should work with the agency responsible for state revolving funds to allow small investor-owned utilities access to these funds.
!	Regulators must recognize the need for advance funding tools (allowing rate recovery in advance of capital needs) using mechanisms such as capital reserve funds and rate stabilization funds to obtain higher bond ratings and reduced financing costs.
!	The commission should consider alternative approaches to ratebase regulation such as the cash basis that is used in the rate regulation of government-owned utilities.
!	The regulatory commission should assist the utility in offering assurance to potential lenders that revenues will be generated to repay the debt such as establishing a dedicated capital funding account.
!	The regulatory agency should adopt more flexible policies and provide incentives for the investor-owned utility to seek capital financing.
!	Regulators should decide small rate cases quickly and consistently and have a small staff that specializes in small water utility cases.
!	Regulators should encourage small systems to participate in financing consortiums, resulting in lower capital costs.
!	The regulatory agency should encourage the acquisition of small utilities.

Source: Panel of Financing Experts.

This report does not present a specific analytic method for selecting the best mechanism (or mechanisms) for financing capital investment in water supply. In the opinion of the author, no evaluation technique can replace informed judgment in making this selection. Regulators must be open to the consideration of alternative financing methods while at the same remaining vigilant about their application.

APPENDIX A

GLOSSARY

AVAILABILITY CHARGE. A charge that is imposed on property owners between the time at which water service is made available to the property and the time when the customer connects to the system and begins receiving service. The availability charge is also known as a dedicated capacity charge.

EQUITY. Equity (an objective concept) and fairness (a subjective concept) are related. Rates and financing methods are fair when perceived by consumers as not providing an unjust advantage to any group of customers. Rates and financing methods are equitable if there is equal treatment of equally situated customers and unequal treatment of unequally situated customers.

INVESTOR-OWNED UTILITY. A utility that is owned by an individual, partnership, or corporation, with equity provided by shareholders. Investor-owned water utilities are subject to regulation by state utility commissions and thus are referred to as jurisdictional utilities.

PRICE ELASTICITY. Price elasticity of demand measures the sensitivity of usage to changes in price. More technically, price elasticity is the ratio of the percentage change in usage in response to a percentage change in price. Estimating price elasticity is an important component of revenue forecasting and water rate design.

PRIVATIZATION. The shifting all or some of the operational or ownership responsibilities from the public sector to the private sector. If this activity shifting only involves a contract between a private firm and an investor-owned utility, it is more appropriately termed as outsourcing.

PUBLICLY OWNED UTILITY. A utility that is created by legislative action of a state or other government agency. A publicly owned utility may be part of municipal government, county government, or regional authority. Publicly owned water utilities are generally not subject to regulation by state public utility commissions.

GLOSSARY, Cont.

REVENUE STABILITY. Revenue stability involves the pattern of revenues from a specific revenue source. Some revenue sources generate revenues in a consistent pattern; other revenue sources generate erratic or unstable revenue flows. For example, fixed water charges provide more stable revenues than commodity charges. Revenue instability can result from conservation rates.

RISK. The exposure of a firm and its investors to the possibility of profit or loss. Risk is increased by increased uncertainty as well as by increased variability of utility costs and revenues. Risks confronting water utilities include business or market risk, financial risk, and regulatory risk.

SYSTEM DEVELOPMENT CHARGE. A contribution of capital for the purpose of financing either recently completed facilities or planned future facilities required to meet the demands of new customers. These charges (also known as impact fees, and capacity fees) are imposed on builders and developers and have the purpose of financing the capital improvements necessary to serve new system customers.

APPENDIX B

PANEL OF FINANCING EXPERTS

Tim Barbee, Assistant Director of Utilities, City of Arlington, Arlington, Texas

Janice A. Beecher, Beecher Policy Research, Inc., Indianapolis, Indiana

James M. Burke, Bureau Economist, Portland Water Bureau, Portland, Oregon

Thomas Catlin, Exeter Associates, Silver Spring, Maryland

Thomas W. Chestnutt, President, A&N Technical Services, Encinitas, California

Jeffrey S. DeWitt, Deputy Finance Director, Phoenix Finance Department, Phoenix, Arizona

David B. LaFrance, Director of Finance, Denver Water, Denver, Colorado

J. Rowe McKinley, Vice-President, Black & Veatch, Kansas City, Missouri

Eric Rothstein, Senior Economist, CH2M Hill, Austin, Texas

Scott J. Rubin, Public Utility Consulting, Selinsgrove, Pennsylvania

Arthur Sirkin, Consultant Administrator, Flagler County Utility Regulatory Interim Authority, Bunnell, Florida

John D. Williams, Chief, Policy Development, Florida Public Service Commission, Tallahassee, Florida

Christopher P.N. Woodcock, President, Woodcock & Associates, Wayland, Massachusetts

The views and opinions expressed by the participants and listed in tables in this report are not necessarily those of the organization, agencies, or firms employing these individuals, nor do they necessarily represent the views of their past or present clients.

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United States General Accounting Office

GAO

Report to Congressional Requesters

August 2002

WATER INFRASTRUCTURE

Information on Financing, Capital Planning, and Privatization

GAO

Accountability * Integrity * Reliability

GAO-02-764

Contents

Abbreviation

EPA **Environmental Protection Agency**

GAO
Accountability * Integrity * Reliability

United States General Accounting Office
Washington, DC 20548

August 16, 2002

The Honorable Robert Smith
Ranking Minority Member
Committee on Environment and Public Works
United States Senate

The Honorable Michael Crapo
Ranking Minority Member
Subcommittee on Fisheries, Wildlife, and Water
Committee on Environment and Public Works
United States Senate

In response to your request, this report provides information on the financing and planning activities of public and private drinking water and wastewater utilities, as well as issues related to privatizing these utility functions.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will send copies to appropriate congressional committees, the Administrator of the Environmental Protection Agency, and the Director of the Office of Management and Budget. We will also make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

Please call me at (202) 512-3841 if you or your staff have any questions. Major contributors to this report are listed in appendix III.

David G. Wood

David G. Wood
Director, Natural Resources
and Environment

Executive Summary

Purpose

According to the Environmental Protection Agency (EPA) and water utility industry groups, communities will need an estimated $300 billion to $1 trillion over the next 20 years to repair, replace, or upgrade aging drinking water and wastewater facilities; accommodate a growing population; and meet new water quality standards. As the agency that regulates drinking water and surface water quality, EPA provides a significant amount of financial assistance for these facilities. Other federal agencies, as well as states, also provide assistance. Given the magnitude of estimated needs, some industry groups are seeking increased federal funding, and the Congress is considering several legislative options.

While drinking water and wastewater utilities use a multitude of funding sources—including federal and state loans and grants, bonds, and other debt and equity instruments—they rely primarily on user charges. Indeed, operating principles established by water utility associations call for fully supporting the utilities' operating and capital costs through user and service charges. Utilities that follow these principles derive a "cost of providing service" to establish their revenue requirements and set their user rates. Depending on the utility, the cost of service may include operation and maintenance expenses, taxes (or payments in lieu of taxes), depreciation, debt service payments, contributions to specified reserves (for example, putting aside funds for future capital needs), other capital expenditures, and a rate of return on the value of the utility's assets. According to water utility associations, utilities should manage their capital assets to maximize the useful life of the assets, control operating costs, and generally enhance the efficiency of their operations. Utilities can develop asset management plans, which should contain such key elements as an assessment of the physical condition of all capital assets, descriptions of the criteria used to measure and report on the condition of the assets, information on the condition in which the assets will be maintained, and a comparison of the planned and actual dollar amounts used to maintain the assets at the established condition level. To address financial and management challenges, some publicly owned utilities have entered into public-private partnerships that use private sector resources in an effort to upgrade or replace deteriorating infrastructure or to operate more efficiently.

The respective Ranking Minority Members of the Senate Committee on Environment and Public Works and its Subcommittee on Fisheries, Wildlife, and Water, asked GAO to examine several issues relating to the funding available to help meet the capital investment needs of the nation's drinking water and wastewater facilities. Given the broad scope of the request, GAO agreed to provide the information in two reports. The first report, issued in November 2001, addressed the amounts and sources of federal and state financial assistance for drinking water and wastewater infrastructure during fiscal years 1991 through 2000.[1]

This second report examines (1) how the amount of funds obtained by large public and private drinking water and wastewater utilities—those serving populations greater than 10,000—through user charges and other local funding sources compare with their cost of providing service, (2) how such utilities manage existing capital assets and plan for needed capital improvements, and (3) what factors influence private companies' interest in assuming the operation or ownership of publicly owned drinking water and wastewater facilities. To address the first and second objectives, GAO mailed questionnaires to 1,425 public and private drinking water systems and 2,391 public and private wastewater systems, which it identified using EPA databases. In the analysis, utilities were weighted to account statistically for all utilities in the population, including those not selected in the sample. Overall, GAO received responses from an estimated 77 percent of the drinking water utilities serving more than 10,000 and 73 percent of the wastewater utilities of this size. GAO used the weighted results to make estimates about the entire population of drinking water and wastewater utilities serving more than 10,000. The percentages cited throughout the report are thus estimates and have 95-percent confidence intervals of plus or minus 10 percentage points or less. (Copies of the questionnaires, including a summary of the utilities' responses, are included as appendixes I and II.) To address the third objective, GAO obtained information from officials with five private companies that have significant experience with privatization agreements and are among the most active participants in this field, either nationally or regionally. In addition, because company officials identified state requirements and policies as a significant factor in privatization decisions, GAO contacted officials in eight states (California, Connecticut, Georgia, Indiana, New Jersey, Pennsylvania, Texas, and Washington) that the companies, EPA, and industry associations identified as having requirements or policies that could affect privatization decisions.

[1]See U.S. General Accounting Office, *Water Infrastructure: Information on Federal and State Financial Assistance*, GAO-02-134 (Washington, D.C.: Nov. 30, 2001).

Background

Americans rely on their drinking water and wastewater utilities to provide clean and safe water for a variety of uses and to protect public health and the environment. Regulated under the Safe Drinking Water Act and the Clean Water Act, respectively, community drinking water systems and wastewater collection and treatment facilities are critical elements in the nation's infrastructure. Local drinking water and wastewater utilities, supported primarily through user charges, have invested billions of dollars over the past century in the facilities that supply the nation's drinking water and treat its wastewater. In many instances, local communities have received financial assistance from federal and state programs. However, even with maintenance and repair activities, infrastructure deteriorates over time and eventually needs replacement and the estimated needs for upgrading existing facilities and building new ones are very large, up to $1 trillion.

In response to growing concerns about the condition of the existing water infrastructure and calls for increased financial assistance, the Congress is considering a number of infrastructure-related proposals. At the local level, community leaders are faced with increasing demands for funding all types of infrastructure and services and must find new ways to control costs or build public support for necessary expenditures. Water utility associations, including the Association of Metropolitan Sewerage Agencies, the Association of Metropolitan Water Agencies, the American Water Works Association, and the Water Environment Federation, have established operating principles and guidance for managing utilities' assets and planning for future capital needs. In addition, public-private partnerships offer one approach to increasing utilities' operational efficiency.

Results in Brief

According to GAO's survey, the amount of funds obtained from user charges and other local sources of revenue was less than the full cost of providing service—including operation and maintenance, debt service, depreciation, and taxes—for over a quarter of drinking water utilities and more than 4 out of 10 wastewater utilities in their most recent fiscal year. Revenues from user charges and other local sources were adequate to cover at least operation and maintenance costs for nearly all of the utilities; however, an estimated 29 percent of the utilities deferred maintenance because of insufficient funding. Revenues from user charges accounted for most of utilities' locally generated funds—at least three-quarters of all funds from local sources for at least three-quarters of utilities. GAO's survey found that about half of the utilities raised their user rates two times or less from 1992 to 2001.

GAO's survey found that more than a quarter of utilities lacked plans recommended by utility associations for managing their existing capital assets, but nearly all had plans that identify future capital improvement needs. Among the utilities that had plans for managing their existing assets, more than half did not cover all their assets or omitted key plan elements, such as an assessment of the assets' physical condition. In addition, while most utilities had a preventive rehabilitation and replacement program for their pipelines, for about 60 percent of the drinking water utilities and 65 percent of the wastewater utilities, the actual rate of rehabilitation and replacement in recent years was less than their desired levels, and many had deferred maintenance, capital expenditures, or both. Almost all utilities reviewed their future capital improvement needs annually, whether or not a formal plan was in place. Many utilities also had plans for financing their future capital needs, but nearly half believed that their projected funding over the next 5 to 10 years would not be sufficient to meet their needs.

A privatization agreement's potential to generate profits is the key factor influencing decisions by private companies that enter into such agreements with publicly owned utilities or the governmental entities they serve, according to the companies GAO contacted. In assessing profit potential, the companies cited several specific criteria, such as the extent of opportunities to enhance operational efficiency, the utility's proximity to the companies' existing operations, the potential for system growth, and the potential need for capital investments. State policies can also influence privatization agreements. For example, two states that GAO contacted restrict the use of design-build-operate contracts, which give a single entity complete control over a project. Other states offer incentives to encourage the takeover of financially troubled public utilities.

Principal Findings

User Charges and Other Local Sources of Funds Covered Much, but Not All, of Utilities' Cost of Providing Service

GAO found that revenues from user charges exceeded the cost of service at an estimated 39 percent of the drinking water utilities and 33 percent of the wastewater utilities. (For the purpose of this analysis, GAO defined a utility's cost of service as operation and maintenance expenses, taxes, depreciation, and debt service.) When revenues from user charges were combined with funding from other local sources, such as hook-up and connection fees and sales of services to other utilities, an estimated 71 percent of the drinking water utilities and 59 percent of the wastewater utilities covered their cost of providing service. For both drinking water and wastewater utilities, GAO did not find statistically significant differences between utilities by the size of the populations they serve; that is, smaller utilities were neither more nor less likely than larger utilities to have covered their cost of providing service with revenues from user charges and other local sources. Similarly, GAO did not find statistically significant differences between drinking water utilities by public or private ownership.[2]

According to GAO's survey results, about 85 percent of drinking water utilities and 82 percent of wastewater utilities covered at least the operation and maintenance portion of the cost of providing service using revenues from user charges alone. Moreover, adding other locally generated funds to the user charges, about 93 percent of the utilities covered their operation and maintenance costs. Operation and maintenance costs are of particular interest because historically, wastewater utilities—as a condition of receiving certain grants under the Clean Water Act—generally were required to cover these costs with user charges. While drinking water utilities are not subject to a similar requirement, both EPA and water industry associations consider adequate user charges to be a key indicator of utilities' financial health. Despite covering operation and maintenance costs, an estimated 29 percent of the utilities deferred maintenance because of insufficient funding.

GAO found that more than half of utilities whose revenues from user charges and other local sources did not cover their cost of providing

[2] GAO did not receive enough responses from privately owned wastewater utilities for a meaningful analysis of ownership types. According to EPA, most privately owned wastewater systems serve populations of less than 10,000.

service raised their rates two times or less during the 10-year period from 1992 to 2001. Overall, GAO found no statistically significant differences in the frequency of rate increases between the utilities that did not cover their costs and those that did.

Many Utilities Lacked Comprehensive Asset Management Plans and Had Deferred Maintenance or Capital Improvements, but Most Had Identified Future Capital Needs

According to GAO's survey, a significant percentage of drinking water and wastewater utilities—about 27 percent and 31 percent, respectively—did not have plans for managing their existing capital assets, although some utilities were in the process of developing such plans. Further, of the utilities with plans, more than half did not include all of their assets or omitted one or more key elements recommended by industry associations; for example, 16 percent of drinking water utilities' plans and 21 percent of wastewater utilities' plans did not include information on the condition level at which the utility intends to maintain the assets. GAO found no statistical differences among utilities of different sizes with regard to the inclusion or exclusion of any of the key elements in their asset management plans. However, GAO found that the plans developed by privately owned drinking water utilities tended to be more comprehensive than those developed by publicly owned utilities.

According to GAO's survey results, some utilities had significant portions of pipelines in poor condition; for example, more than one-third of the utilities had 20 percent or more of their pipelines nearing the end of their useful life. Nevertheless, for about 60 percent of drinking water utilities and 65 percent of wastewater utilities, the actual levels of pipeline rehabilitation and replacement in recent years were less than the utilities' desired levels. For example, GAO's survey indicates that roughly half of the utilities actually rehabilitated or replaced 1 percent or less of their pipelines annually, even though an estimated 89 percent of drinking water utilities and 76 percent of wastewater utilities believed that a higher level of rehabilitation and replacement should be occurring. Further, in each of three categories—maintenance, minor capital improvements, and major capital improvements—about one-third or so of the utilities had deferred expenditures in their most recent fiscal years, and 20 percent had deferred expenditures in all three categories. With one exception, there were no statistically significant differences among utilities of different sizes; however, GAO found that public drinking water utilities were more likely than their privately owned counterparts to defer maintenance and major capital projects.

Overall, GAO's survey results indicate that about 90 percent of drinking water and wastewater utilities had capital improvement plans to identify future capital needs, and about 90 percent of utilities reviewed their needs annually whether or not they had developed formal plans. About 95 percent of the utilities' capital improvement plans covered 5 years or more—with about 25 percent of drinking water utilities and about 20 percent of wastewater utilities covering 10 years or more. The smallest systems (those serving 10,001 to 25,000 people) were slightly less likely than larger systems to have such plans. Most of the utilities with capital improvement plans also had plans for financing the projects they identified; according to GAO's survey, 86 percent of the utilities had such financing plans, including virtually all of the largest utilities (those serving populations of over 100,000). However, about 45 percent of the drinking water and wastewater utilities anticipated that their projected funding would not be sufficient to cover future needs over the next 5 to 10 years. Regarding this outlook, there were no statistically significant differences among wastewater utilities of different sizes; however, the largest drinking water utilities were less likely to believe that their projected revenues would be insufficient to cover anticipated future needs than their smaller counterparts. Also, public drinking water utilities were somewhat more likely than privately owned systems to have concerns about future funding.

Profit Potential Is Key Factor in Private Companies' Decisions to Assume Operation or Ownership of Drinking Water or Wastewater Utilities

Privatization agreements range from contracts to operate and maintain local drinking water or wastewater facilities to outright ownership by private entities. Not surprisingly, all five of the companies GAO contacted evaluate the potential for profits when considering entering into privatization agreements. Criteria important to assessing the profitability of a proposed utility privatization agreement include the potential to improve the efficiency of the utility's operations; the proximity to the company's other utility operations; the potential for system growth; the terms of a proposed contract; and the potential need for capital investments. Each of the five companies GAO contacted employs a somewhat different business strategy in its pursuit of privatization agreements, such as placing more emphasis on contract operations rather than assuming ownership of utilities or focusing on utilities of particular sizes or in particular locations. Differences in the companies' business strategies had some influence on the relative importance of the factors to each company. In addition to identifying the site-specific factors they consider in evaluating privatization opportunities, representatives from all five companies also provided comments on state requirements or policies that can facilitate or impede privatization arrangements.

Officials in eight states GAO contacted said their primary interest is the delivery of adequate service to the public, whether the service is provided by publicly or privately owned utilities. However, some requirements and policies can affect companies' privatization decisions. For example, among the states GAO contacted, state regulators in Indiana and Pennsylvania have established programs that provide incentives to acquire or take over troubled utilities. In Indiana, for example, the acquiring utility is often permitted an "acquisition adjustment," which allows the utility to charge customers higher rates. On the other hand, state policies may have the effect of limiting privatization; two of the states GAO contacted restrict the use of design-build-operate contracts. In Texas, for example, the state requires the use of qualification-based criteria for selection of engineering design services and a bidding process for construction services, requirements that effectively preclude combining design, construction, and operating services in a single procurement.

Agency Comments

GAO provided a draft of this report to EPA for its review and comment. GAO received comments from officials in EPA's Office of Water, including the Office of Ground Water and Drinking Water and the Office of Wastewater Management. EPA agreed with the information presented in the report and characterized the findings as interesting and informative. EPA officials also provided several technical comments and clarifications, which GAO incorporated as appropriate.

Chapter 1: Introduction

Americans rely on their drinking water and wastewater utilities to provide clean and safe water for a variety of uses and to protect public health and the environment. Regulated under the Safe Drinking Water Act and the Clean Water Act, respectively, community drinking water systems and wastewater collection and treatment facilities are critical elements in the nation's infrastructure. Local drinking water and wastewater utilities, supported primarily through user charges, have invested billions of dollars over the past century to create the treatment, collection, storage, and distribution facilities that supply the nation's drinking water and treat its wastewater, in accordance with applicable federal and state quality standards. In many instances, local communities have also received financial assistance from federal or state programs to improve or expand their water infrastructure. Even with maintenance and repair activities, infrastructure deteriorates over time and eventually needs replacement. According to recent estimates, the level of investment that will be required over the next 20 years to repair, replace, or upgrade aging facilities; accommodate the nation's growing population; and meet new quality standards will be very large, up to $1 trillion. Moreover, following the terrorist attacks of September 11, 2001, both drinking water and wastewater utilities may have to make additional investments to increase the security of their operations.

In response to growing concerns about the condition of the existing water infrastructure and calls for increased financial assistance, the Congress is considering a number of infrastructure-related proposals. At the local level, utility managers must find new ways to control costs or build public support for increasing the rates charged to customers. Among the options available to help local utilities meet the challenges they face are ensuring that revenues are adequate to cover costs, finding more cost-effective ways to manage utility assets, and entering into public-private partnerships.

Federal, State, and Local Entities Play Important Roles in Ensuring Safe Drinking Water and Effective Wastewater Treatment

The Environmental Protection Agency (EPA) sets standards for the quality of drinking water and wastewater and issues other regulations and guidance to implement the requirements of the Safe Drinking Water Act and the Clean Water Act. Under the Safe Drinking Water Act, EPA is required to establish (1) standards or treatment techniques for contaminants that could adversely affect public health and (2) requirements for monitoring the quality of drinking water and for ensuring the proper operation and maintenance of water systems. The Clean Water Act's National Pollutant Discharge Elimination System program limits the types and amounts of pollutants that industrial and municipal wastewater treatment facilities may discharge into the nation's surface waters. EPA has issued national guidance and regulations to assist the states in establishing standards to protect the quality of their waters and in issuing permits to facilities to limit discharges of pollutants.

Both federal and state agencies also provide a significant amount of funding for drinking water and wastewater infrastructure through grant and loan programs. In November 2001, we reported that from fiscal year 1991 through fiscal year 2000, nine federal agencies made available about $44 billion for capital improvements at drinking water and wastewater systems, and states made available about $25 billion over the same period.[1] EPA represents the largest source of financial assistance at the federal level through its Drinking Water and Clean Water State Revolving Funds, contributing about 56 percent of the total. Under these programs, EPA provides grants to the states to capitalize revolving loan funds. The states, which are required to contribute matching funds equal to 20 percent of the EPA grants, make loans to local communities or utilities; as loans are repaid, the states' revolving loan funds are replenished. In addition to contributing over $10 billion to match EPA's capitalization grants for the Drinking Water and Clean Water State Revolving Funds, the states made over $9 billion available under state-sponsored grant and loan programs and provided about $6 billion through general obligation and revenue bonds and other funding mechanisms.

At the local level, a variety of public and privately owned utilities operate thousands of systems that supply drinking water and treat wastewater for millions of Americans. In total, about 55,000 community drinking water

[1]In constant year 2000 dollars. See U.S. General Accounting Office, *Water Infrastructure: Information on Federal and State Financial Assistance*, GAO-02-134 (Washington, D.C.: Nov. 30, 2001).

systems and nearly 30,000 wastewater treatment and collection facilities are subject to numerous treatment, testing, and operational requirements under the Safe Drinking Water Act and the Clean Water Act, respectively. Although many of these utilities are quite small, particularly in the case of drinking water systems,[2] larger utilities serve most of the U.S. population and account for most of the infrastructure needs identified in periodic surveys of such needs conducted by EPA. Specifically, according to EPA's Safe Drinking Water Information System, as of January 2001, 4,079 utilities, or about 7 percent of all community water systems, each served more than 10,000 people and accounted for about 65 percent of the estimated infrastructure needs for drinking water utilities. In the case of wastewater utilities, about 8,744 treatment and collection facilities, or about 29 percent of the total, are estimated to serve more than 10,000 people. These facilities account for approximately 89 percent of the estimated infrastructure needs for wastewater utilities.[3]

Publicly owned drinking water and wastewater utilities include systems owned by municipalities, townships, counties, water and/or sewer districts, and water and/or sewer authorities. Private ownership encompasses a broad range of owners, from homeowners' associations, mobile home parks, and other entities whose primary business is unrelated to water supply or wastewater treatment, to larger, investor-owned companies. About half of the nation's drinking water systems and an estimated 20 percent of the wastewater systems are privately owned, according to EPA and industry sources. According to EPA, most of the privately owned drinking water and wastewater systems serve populations of less than 10,000.

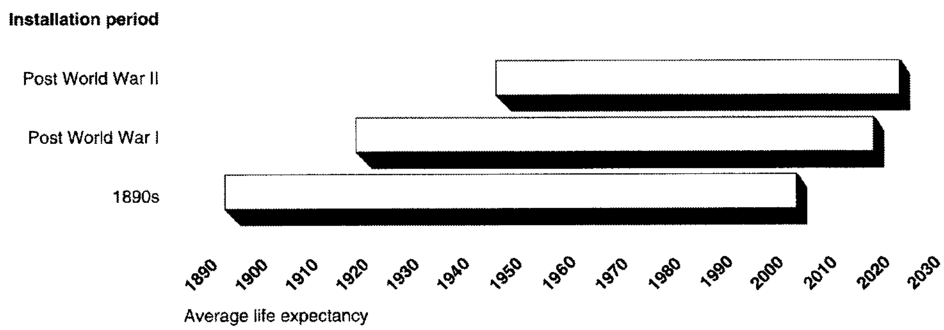
[2]For example, nearly 60 percent of the community drinking water systems serve populations of 500 or fewer.

[3]For the purposes of our review, we focused on wastewater treatment facilities only to avoid double counting collection facilities that serve multiple treatment plants. According to an EPA official, wastewater treatment facilities serving 10,000 or more people account for approximately 65 percent of the estimated infrastructure needs for wastewater utilities.

Addressing Future Drinking Water and Wastewater Infrastructure Needs Will Require Major Investments

EPA and a variety of industry groups are predicting that major investments will be needed to upgrade, repair, or replace existing infrastructure; meet demands for additional capacity; or comply with new regulatory requirements. Pipeline rehabilitation and replacement represents a significant portion of the projected infrastructure needs. According to EPA estimates, for example, at least half of the drinking water and wastewater infrastructure need is in the form of pipes buried under ground. A study sponsored by a major water industry association concluded that much of the existing pipe network is at or near the end of its expected lifespan.[4] Using average life estimates for different types of pipe and counting the years since the lines were originally installed, the study predicts that drinking water utilities will face significant repair and replacement costs over the next 3 decades. Other studies make similar predictions for the pipelines owned by wastewater utilities.[5] Figure 1 shows the estimated life expectancy of the pipelines installed during major periods of utility growth.

Figure 1: Estimated Life of Pipes According to Major Eras of Water Main Installation



Source: American Water Works Association Water Industry Technical Action Fund, *Dawn of the Replacement Era: Reinvesting in Drinking Water Infrastructure* (Denver, Colo.: May 2001) pp. 10-11.

[4]American Water Works Association Water Industry Technical Action Fund, *Dawn of the Replacement Era: Reinvesting in Drinking Water Infrastructure* (Denver, Colo.: May 2001).

[5]For example, see Water Environment Research Foundation, *New Pipes for Old: A Study of Recent Advances in Sewer Pipe Materials and Technology* (2000).

While the size, period covered, and specific assumptions of individual estimates vary, the amount needed for future capital investments in water and wastewater infrastructure will be substantial. Several recent studies project future infrastructure needs over a 20-year period:

- According to EPA's 1999 survey of drinking water infrastructure needs, the estimated needs would be at least $150.9 billion through 2019, including an estimated $83.2 billion just for water transmission and distribution lines.[6]
- Similarly, EPA's 1996 survey of "clean water" needs estimated that total wastewater infrastructure-related needs will be about $128 billion through 2016.[7] In a subsequent analysis, EPA estimated that an additional $56 billion to $87 billion would be needed to correct existing sanitary sewer overflow problems.
- In April 2000, the Water Infrastructure Network, a consortium of industry, municipal, state, and nonprofit associations, projected needs of up to 1 trillion dollars over the next 20 years for drinking water and wastewater utilities combined, when both the capital investment needs and the cost of financing are considered.[8]
- In May 2002, the Congressional Budget Office estimated that the cost of drinking water and wastewater infrastructure over the next 20 years would be $492 billion under a low-cost scenario and $820 billion under a high-cost scenario, including both the cost of physical capital and interest on loans and bonds.[9]

Whatever the level of investment turns out to be, the needs will be likely be met by some combination of local, state, and federal funding sources. As the Congressional Budget Office noted in its recent report, society as a whole will ultimately foot the bill, whether through the rates charged to users or through federal, state, or local taxes.

[6]U.S. Environmental Protection Agency, *Drinking Water Infrastructure Needs Survey: Second Report to Congress*, EPA 816-R-01-004 (Washington, D.C.: February 2001).

[7]U.S. Environmental Protection Agency, *1996 Clean Water Needs Survey Report to Congress*, EPA 832-R-97-003 (Washington, D.C.: September 1997).

[8]Water Infrastructure Network, *Clean & Safe Water for the 21st Century* (April 2000).

[9]Congressional Budget Office, *Future Investment in Drinking Water and Wastewater Infrastructure*, (Washington, D.C.: May 2002). The report states that assumptions about the rate at which drinking water pipes are replaced, the savings associated with improved efficiency, the costs of controlling combined sewer overflows, and the borrowing term are primarily responsible for the difference between the low and high estimates.

Adequacy of User Charges Is Key Indicator of Sound Management at Drinking Water and Wastewater Utilities

Drinking water and wastewater utilities need revenue to maintain current service levels, meet new demands for service, adequately maintain existing plant and equipment, and plan for future needs in an orderly manner. To accomplish these goals, water industry associations generally support the principle that utilities should generate enough revenue through user rates and service charges to fully cover the cost of providing service, without relying on subsidies from other revenue sources.[10] That is, the rates that utilities charge their customers should be sufficient to finance all of the utilities' operating and maintenance expenses as well as capital costs. For example, according to a group of water industry associations known as the H2O Coalition, water utilities should move toward becoming self-sustaining by charging their customers rates that reflect the full cost of service, thus ensuring that utilities will get as much of the revenues they need as possible from their customers.[11] EPA's Office of Water also supports the concept of fiscal sustainability for water utilities and sees rates that result in revenues sufficient to meet the cost of service as a measure of the utilities' financial health.

In some instances, drinking water and wastewater utilities may have to establish user rates that meet certain minimum requirements as a condition of receiving federal or state financial assistance. For example, the Clean Water Act requires wastewater utilities that received construction grants under title II of the act to establish rates that generate enough revenue to cover operation and maintenance costs. Less specific requirements apply to wastewater utilities that receive loans under the Clean Water State Revolving Fund Program. Although the Safe Drinking Water Act does not contain any explicit requirements for minimum user charges at drinking water utilities, EPA has addressed the issue indirectly in guidance to the states. Under the Safe Drinking Water Act Amendments of 1996, states are required to develop programs to ensure that drinking water systems have the financial, managerial, and technical capacity to comply with national drinking water regulations. EPA's guidance on implementing such programs suggests that the criteria for assessing the

[10]Among the associations that support the principle that utilities should be self-sustaining are the American Water Works Association, the Association of Metropolitan Sewerage Agencies, the Association of State Drinking Water Administrators, the National Association of Water Companies, the National Council for Public Private Partnerships, and the Water and Wastewater Equipment Manufacturers.

[11]The H2O Coalition includes the National Association of Water Companies, the National Council for Public-Private Partnerships, the Water and Wastewater Equipment Manufacturers Association, and the Association of State Drinking Water Administrators.

systems' financial capacity include a determination of whether water rates and charges are adequate to cover the cost of water.[12]

Utilities Use Approaches Such as Asset Management and Privatization to Increase Operational Efficiency

In addition to maintaining adequate user charges, utilities can ensure that their revenues are sufficient by increasing their operational efficiency and thus controlling their costs. One approach recommended by industry experts is "asset management." The goal of asset management is to manage infrastructure assets so that the total cost of owning and operating them is minimized and desired customer service levels are maintained. The asset management process involves assessing the condition of a system's infrastructure assets, estimating the life expectancy of these assets, and ensuring that sufficient funds are allocated over the life of the assets to optimize their value.

Asset management is seen as particularly relevant to the water utility industry because drinking water and wastewater utilities are capital-intensive and have a sizeable investment in pipes and other assets with a relatively long service life. According to a comprehensive industry handbook on managing capital assets, there is a growing awareness among water utilities that "preserving the life and function of infrastructure assets will help optimize operations and maintenance and identify needed capital resources, thereby reducing funding gaps between future capital needs and available financial resources."[13] Given the magnitude of the estimates for future infrastructure needs, it is important for utilities to adopt a strategy for managing the repair and replacement of key assets as cost-effectively as possible.

In recent years, privatization of public facilities and services, particularly at drinking water utilities, has been occurring in the United States at an increasing rate. Some municipal drinking water and wastewater utilities have explored privatization as another option for increasing operational efficiency. Privatization is commonly defined as any process aimed at shifting functions and responsibilities, in whole or in part, from the municipal government to the private sector. Municipalities may turn to

[12]U.S. Environmental Protection Agency, *Guidance on Implementing the Capacity Development Provisions of the Safe Drinking Water Act Amendments of 1996*, EPA 816-R-98-006 (Washington, D.C.: July 1998).

[13]Association of Metropolitan Sewerage Agencies, *Managing Public Infrastructure Assets to Minimize Cost and Maximize Performance*, p. 4.

privatization agreements to address issues such as needed infrastructure improvements, rising costs, or more stringent regulatory requirements.

Privatization can take different forms, ranging from contracting for specific services to the actual sale of a facility to a private company. The most common form of privatization is contracting, which typically entails a competition among private bidders to perform certain activities. In the case of drinking water and wastewater utilities, such activities typically include operation and maintenance. When a municipality contracts with a private company for services, the government remains the financier and has management and policy control over the quality of services to be provided. In some instances, privatization involves the transfer of the ownership of utility assets from a municipality to the private sector. Once the assets have been sold, the government generally has no role in their financial support, management, or oversight.

Objectives, Scope, and Methodology

The Ranking Minority Member, Senate Committee on Environment and Public Works, and the Ranking Minority Member, Subcommittee on Fisheries, Wildlife, and Water, Senate Committee on Environment and Public Works, asked us to examine several issues relating to the funding available to help meet the capital investment needs of the nation's drinking water and wastewater facilities.[14] This report provides information on

- how the amount of funds obtained by large public and private drinking water and wastewater utilities—those serving populations greater than 10,000—through user charges and other local funding sources compare with the cost of providing service,
- how such utilities manage existing capital assets and plan for needed capital improvements, and
- what factors influence private companies' interest in assuming the operation or ownership of publicly owned drinking water and wastewater facilities.

To address the first two objectives, we obtained information on utility finances and capital management practices by surveying, using a mailed questionnaire, drinking water and wastewater utilities that serve

[14]As noted earlier, our November 2001 report addressed the amounts and sources of federal and state financial assistance for drinking water and wastewater infrastructure during fiscal years 1991 through 2000. See GAO-02-134.

populations greater than 10,000. We developed similar but separate questionnaires, one for drinking water utilities and one for wastewater utilities. We focused on utilities serving populations of more than 10,000 because they (1) accounted for a large share of infrastructure needs and (2) were more likely than their smaller counterparts to have the means to respond to our survey. A copy of the drinking water utility questionnaire, with summary response data, is in appendix I, and a copy of the wastewater utility questionnaire, with summary response data, is in appendix II.

We obtained contact information for the drinking water utilities from EPA's Safe Drinking Water Information System database. We mailed questionnaires to all 480 private drinking water utilities and to a sample of 945 public drinking water systems, stratified by size of population served (the size categories appear on the questionnaires), identified in the database. (Thus, we sent questionnaires to a total of 1,425 utilities.) We obtained contact information for the public and private wastewater utilities from EPA's Clean Water Needs Survey database and EPA's Permit Compliance System database.[15] EPA does not collect information specifically on the size of the population served by wastewater utilities. However, EPA officials estimate that facilities that process more than 1 million gallons of wastewater per day are roughly equivalent to facilities that serve populations of more than 10,000 people. Thus, we used EPA's data on plant capacity to approximate the sizes of wastewater utilities. We then mailed questionnaires to all 2,391 of the systems estimated on this basis to serve populations greater than 10,000.

We included on the questionnaires a "screening" question to make certain that the responses we obtained and used were in fact from utilities that served populations greater than 10,000. We obtained 821 useable responses from drinking water utilities and 1,113 useable responses from wastewater utilities. In the analysis, utilities were weighted to account statistically for all utilities serving populations greater than 10,000, including those not selected for our sample. Overall, using response data from the screening question and from nonrespondent follow-up efforts to adjust the estimated number of drinking water and wastewater utilities serving populations greater than 10,000, we estimate that 77 percent of the

[15]We did not send questionnaires to drinking water and wastewater utilities whose ownership was specified as "federal government," "state government," "native American," or "not specified."

drinking water utilities serving more than 10,000 people and 73 percent of the wastewater utilities of this size responded to the survey. We used the weighted results to make estimates about the entire population of such drinking water and wastewater utilities. Therefore, all utility percentages cited in the remainder of the report are estimates and have some sampling error associated with them. All estimates cited have 95-percent confidence intervals of plus or minus 10 percentage points or less; that is, we are 95 percent confident that the "actual" population value is contained in an interval of 10 percentage points above or below the estimate. We used these sampling errors to assess statistically significant differences between percentages as well.

In addition to sampling errors, surveys can be subject to other types of systematic error or bias that can affect the results, commonly referred to as nonsampling errors. For example, questions may be misinterpreted; the respondents, as a group, may differ from those who did not respond in ways that are important; or response data could be erroneously transcribed or entered into a database. We took several steps in an attempt to reduce such errors. For example, to minimize the chances of questions being misinterpreted, we developed our survey questions with the aid of a survey specialist. We discussed the questionnaire with officials from the EPA's Office of Water; the Association of Metropolitan Sewerage Agencies; the American Water Works Association; the Water Environment Federation; three consulting firms that specialize in the water utility industry: Beecher Policy Research, Inc., Hayden Reynolds & Associates, Pty. Ltd., and PA Consulting Group; and public utility commissions in the states of West Virginia and Wisconsin. In addition, we pretested the questionnaires with five drinking water utilities and five wastewater utilities.[16] To maximize our response rate, we sent reminder postcards and mailed two follow-up questionnaires to all nonrespondents. All data were double keyed during data entry, and we verified a sample of the resulting automated data. We ran various edit checks and other computer analyses to identify inconsistencies and potential errors in the data, and a technical specialist independently reviewed all computer programs.

One of our objectives was to compare public and privately owned utilities. However, we did not receive enough responses from privately owned

[16]The five drinking water and five wastewater utilities were chosen to represent a variety of size categories (based on population served by each utility) and both public and private ownership.

wastewater utilities for a meaningful analysis (as noted previously, according to EPA, most privately owned wastewater systems serve populations of less than 10,000 people). Therefore, our analyses concerning utility ownership type were limited to drinking water utilities only. In comparing utilities according to the size of the population served, we collapsed the size categories into four: utilities serving populations of 10,001 to 25,000; 25,001 to 50,000; 50,001 to 100,000; and over 100,000.

To address the third objective, we interviewed officials from five private companies that have significant experience with privatization agreements and are among the most active participants in this field either nationally or regionally. The companies are American Water Works Service Company, Inc., United States Filter Corporation, and United Water (companies that operate nationally in a total of 40 states); ECO Resources, Inc., which operates principally in the Southwest; and Philadelphia Suburban Water Company, which focuses its operations in the mid-Atlantic and Midwest. In addition, because company officials identified state requirements and policies as a significant factor in their investment decisions, we interviewed officials from eight states (California, Connecticut, Georgia, Indiana, New Jersey, Pennsylvania, Texas, and Washington) that the companies, EPA, or industry officials identified as having requirements or policies that could affect privatization.

We conducted our work between May 2001 and July 2002 in accordance with generally accepted government audit standards.

Chapter 2: User Charges and Other Local Sources of Funds Covered Much, but Not All, of Utilities' Cost of Providing Service

According to our survey, the amount of funds obtained from user charges and other local sources of revenue was less than the full cost of providing service—including operation and maintenance, debt service, depreciation, and taxes—for an estimated 29 percent of drinking water utilities and 41 percent of wastewater utilities. (Our survey requested information on utilities' revenues and costs during their most recently completed fiscal year.) Revenues from user charges and other local sources were adequate to cover at least operation and maintenance costs for over 93 percent of the utilities, but about 29 percent of the utilities deferred maintenance during the same time period because of insufficient funding. Revenues from user charges usually accounted for most of utilities' locally generated funds. Our survey found that about half of the utilities raised their user rates infrequently—once, twice, or not at all—from 1992 to 2001.

Funds Collected from Local Sources Were Often Less Than Utilities' Cost of Providing Service

We found that revenues from user charges and other local sources often fell short of utilities' cost of providing service, as defined below. According to EPA and major water industry associations, in order to be self-sustaining, drinking water and wastewater utilities must recover the full cost of providing service through their user rates and service charges. Rates that generate sufficient revenue to cover the full cost of service lessen the need for external assistance, such as federal or state grants and loans. Determining the cost of service establishes a utility's revenue requirements and, accordingly, can serve as a basis for its rate structure.

According to the National Regulatory Research Institute, "determining utility revenue requirements involves an examination of aggregate annual costs, including operating as well as capital costs," to derive the utility's cost of providing service.[1] In a November 1993 report, the Institute explained that water utilities generally use one of two basic methods of determining their revenue requirements for the purpose of setting user rates, largely depending on whether the utility is public or privately owned:[2]

[1]The National Regulatory Research Institute was established by the National Association of Regulatory Utility Commissioners in 1976 at the Ohio State University and is the official research arm of the association. The Institute provides research and assistance to state public utility commissions and other selected national and international clients. See National Regulatory Research Institute, *Meeting Water Utility Revenue Requirements: Financing and Ratemaking Alternatives* (Nov. 1993) p. 63.

[2]*Meeting Water Utility Revenue Requirements: Financing and Ratemaking Alternatives*, p. 64.

- Under the "utility" approach, which is typically used by investor or privately owned utilities, the total cost of service includes operation and maintenance expenses, taxes, depreciation, and a rate of return on the value of the utilities' assets less accumulated depreciation.
- Under the "cash needs" approach, used by many public utilities, the total cost of service includes operation and maintenance expenses, tax equivalents (e.g., payments in lieu of taxes), debt service payments (including both interest charges and repayment of principal), contributions to specified reserves, and capital expenditures not financed by either debt or contributions.

To determine whether revenues from user charges and other local sources were large enough to cover the cost of providing service among the utilities covered by our survey, we adapted the utility approach. We developed a modified utility method because it allowed us to (1) adopt a standard approach to deriving the "cost of providing service" for both public and privately owned utilities, thereby enabling more meaningful summaries and comparisons among all of the utilities and (2) make the most effective use of the categories of cost data we collected. Specifically, to calculate the cost of service, we included the amounts reported for operation and maintenance expenses, taxes, and depreciation.[3] We also included the amounts reported as debt service (including interest charges and repayment of principal) as a surrogate for rate of return, a category for which our survey did not request information.[4] Because of the approach we used, we may have overstated some utilities' costs and thus the number of utilities that did not cover their costs. The reason is that for some utilities the portion of debt service attributable to repayment of principal may have been covered, in part, by the inclusion of depreciation in computing the cost of service.

[3]Our survey allowed utilities to report miscellaneous costs under an "Other" category, and some utilities did so. When appropriate, we recategorized these costs. For example, some public systems reported transfers to other city departments in the Other category; when the survey document indicated that the transfer was for administrative services, such as accounting or legal services, we included the amount in the "Operations and Maintenance" category. When it was not possible to discern a more appropriate category for particular costs, we included them in the calculation of cost of service as other costs.

[4]We considered using the cash needs approach to calculate the cost of service because most of our respondents were public utilities and, as such, were more likely to use the applicable cost categories. However, while our survey requested information on the amount of utilities' capital expenditures during their most recently completed fiscal year, the survey did not specifically request information on "capital expenditures not financed by either debt capital or contributions."

User Charges Represent One of Many Sources of Funding Used by Utilities

Our survey showed that virtually all utilities obtained revenues from user charges during their most recently completed fiscal year. Other common funding sources included hook-up and connection fees and interest earnings, used by an estimated 80 to 90 percent of utilities. Table 1 summarizes the types of funding used by drinking water and wastewater utilities during their most recently completed fiscal year, according to our survey.

Table 1: Estimated Percentages of Utilities That Used Each Source of Funding in Their Most Recently Completed Fiscal Year

Funding source	Estimated percentage of utilities using funding source[a]	
	Drinking water	Wastewater
User charges	98	97
Other local revenues		
Property taxes	8	10
Sales to other utilities	42	32
Product sales	[b]	12
Special operating cost levies	3	39
Interest earned	77	78
Assessments	14	21
Permit and inspection fees	41	50
Hook-up, connection, or tap fees	89	78
Reserves	35	37
Other	51	29
Grants		
Federal grants	16	18
State grants	21	31
Other grants	4	4
Debt and equity		
Federal loans	12	8
State loans	25	40
Commercial loans	9	6
Revenue bonds	36	36
General obligation bonds	19	23
Private activity bonds	2	<1
Sale of stock	2	0
Other short-term debt	8	5
Other long-term debt	7	3
Other debt and equity instruments	2	1
Other	7	7

[a]Our survey did not collect information on the dollar amount of funding generated by nonlocal sources.

[b]Our survey also did not collect information on whether drinking water utilities obtained revenues from product sales. This may account for the large percentage of such utilities that used the Other category under the Other local revenues category (51 percent compared to 29 percent of wastewater utilities).

Source: GAO's analysis of survey data.

User Charges and Other Local Revenues Were Less Than Many Utilities' Cost of Providing Service

Using the modified utility approach described earlier, we analyzed our survey data to compare utilities' costs and revenues. Among other things, we found that for many utilities, revenues from user charges alone were not enough to cover the cost of service in their most recently completed fiscal year. Specifically, we found that revenues from user charges exceeded the cost of service at an estimated 39 percent of the drinking water utilities and 33 percent of the wastewater utilities. However, combining revenues from user charges with funding from other local sources, such as hook-up and connection fees and sales of services to other utilities, we found that more utilities were able to cover their cost of providing service. Specifically, for an estimated 71 percent of the drinking water utilities and 59 percent of the wastewater utilities, user charges plus other local revenues exceeded the cost of providing service.

We analyzed our survey data to determine if there were any statistically significant relationships between certain utility characteristics and the utilities' ability to cover costs with user charges and/or other local revenues. First, we examined these relationships for both (1) the size of the population served by the utilities and (2) the type of ownership (public or private). We found the following:

- For both drinking water and wastewater utilities, there were no statistically significant differences between utilities based on the size of the populations they served; that is, smaller utilities were neither more nor less likely than larger utilities to have covered their cost of providing service, whether we looked at revenues from user charges alone or revenues from all local sources.
- Among drinking water utilities, ownership type did make a difference when comparing the cost of providing service with revenue from user charges alone. We found that 62 percent of public drinking water utilities did not cover their cost of service with user charges alone, compared with 44 percent of privately owned systems. However, when we included revenues from other local sources in the analysis, we found no statistical difference between public and privately owned drinking water utilities.

EPA has reached similar conclusions about the ability of some utilities to cover their costs. For example, in a July 1999 report on the characteristics of small drinking water systems, defined as those serving less than 10,000 people, EPA compared such systems to larger ones serving more than 10,000 people—the same group included in our study. EPA reported that an estimated 20 percent of the larger systems did not have sufficient revenues to cover their debt service costs after paying operating expenses.[5] In the case of wastewater utilities, a September 1990 study on user fees reported that when total wastewater revenues were compared to total wastewater treatment costs, a significant percentage of the utilities included in the study—31 percent of those serving populations of 10,000 to 100,000 and 26 percent of those serving over 100,000 people—were operating with a revenue shortfall.[6] As defined in the study, total treatment costs consisted of debt repayment costs plus operation, maintenance, and equipment replacement costs.

We next analyzed our survey data to determine if there were any statistically significant relationships between utilities' ability to cover costs with user charges and/or other local revenues and other characteristics. Overall, we found few significant differences; that is, for the most part, utilities that covered their cost of providing service with revenues from user charges and/or other local sources did not differ—on the basis of characteristics we examined—from those that did not. More specifically, we found the following regarding utilities' ability to cover their cost of providing service with user charges and other local revenues and the following characteristics:

- *Use of federal or state grants or loans.* An estimated 24 percent of the drinking water utilities and 36 percent of the wastewater utilities that did not cover their costs obtained federal and/or state grants during their most recently completed fiscal year. These utilities obtained grants at about the same rate as the drinking water and wastewater utilities that did cover

[5]U.S Environmental Protection Agency, *National Characteristics of Drinking Water Systems Serving Populations Under 10,000*, EPA 816-R-99-010 (Washington, D.C.: July 1999). Among other things, the report compares the financial characteristics of several different subsets of small systems serving less than 10,000 people to the systems that serve more than 10,000 people in a number of ways, including the ratio of annual debt service payments to net available revenue (i.e., total revenues minus operating and maintenance expenses).

[6]U.S. Environmental Protection Agency, *National Wastewater User Fee Study of the Construction Grants Program*, EPA 430/09-90-011 (Washington, D.C.: September 1990).

their costs. Similarly, when we included utilities that received federal or state loans in our analysis—in addition to the utilities that received assistance from grants—we found that an estimated 43 percent of the drinking water utilities and 60 percent of the wastewater utilities that did not cover their costs used some form of federal or state grant or loan. These utilities received assistance at about the same rate as utilities that did cover their costs.

- *Dedication of rate revenues for specific purposes.* We found no statistical differences regarding the extent to which utilities' rates included amounts to cover the cost of preventive rehabilitation and replacement programs for pipelines. Based on our survey, an estimated 85 percent of the utilities' rates included such amounts, whether or not the utilities covered their cost of providing service. Similarly, both drinking water and wastewater utilities that covered their cost of service were no more likely than those that did not to dedicate a portion of revenues from user charges specifically to future capital needs. Overall, according to our survey, about 70 percent of drinking water and wastewater utilities dedicated a portion of their user charges to future capital needs in developing their rates.
- *Existence of rate relief or other subsidy for lower-income customers.* About the same percentage of utilities offered some type of subsidy to lower-income customers—about 14 percent of the drinking water utilities and about 13 percent of the wastewater utilities—whether or not the utilities covered their cost of service.

More comprehensive information might have allowed us to draw some clearer distinctions between utilities that did and did not cover their costs. However, to limit the burden on our survey respondents, we did not ask utilities to report the amount of any assistance they received, and we requested data on only the most recently completed fiscal year.

Funds from Local Sources Generally Exceeded Operation and Maintenance Costs

Annual operation and maintenance costs are those associated with operating and maintaining a utility—including the costs of labor, energy, chemicals, and accounting services. Operation and maintenance costs are of particular interest because of certain requirements imposed on many wastewater utilities as a condition of receiving construction grants under the Clean Water Act. Specifically, the wastewater utilities are required to generate sufficient revenues through user charges to cover operation and maintenance costs.[7] According to EPA's 1990 report on wastewater user fees, all wastewater utilities serving more than 10,000 people at that time received such grants.[8] While drinking water utilities are not subject to a similar requirement, both EPA and key water industry associations consider adequate user charges to be a key indicator of utilities' financial health.

According to our survey results, an estimated 85 percent of drinking water utilities and 82 percent of wastewater utilities were able to cover their operation and maintenance costs using revenues from user charges alone. Moreover, adding other locally generated funds to the user charges, we estimated that over 93 percent of the utilities were able to cover their operation and maintenance costs. With one exception, we also found that a utility's size or type of ownership did not influence its ability to cover operation and maintenance costs. However, privately owned drinking water utilities were somewhat more likely to have sufficient revenues from user charges to cover their operation and maintenance costs than public utilities (the estimates were 91 percent compared to 85 percent).

Our findings are consistent with EPA's July 1999 report on the characteristics of small drinking water systems, which compared systems serving less than 10,000 people to systems serving more than 10,000 people. EPA reported that 13 percent of the larger systems (those serving populations of more than 10,000) had operation and maintenance

[7]The user charge requirement applies to construction grants awarded under title II of the Clean Water Act. According to EPA, although most of these grants were expended long ago, the user charge requirement applies "in perpetuity," as long as the facilities for which the grants were used remain in operation.

[8]*National Wastewater User Fee Study of the Construction Grants Program*, p. 2. The last year for which the Congress authorized funding for construction grants was 1990.

expenses that exceeded their operating revenues.[9] For the purposes of its study, EPA defined operating revenues as the sum of water sales and the following water-related revenues: connection fees, inspection fees, developer fees, usage fees, other fees, and general fund revenues. Interest earned, primary business revenues, fines or penalties, and other water related revenues were not included. Although our results indicate that a smaller percentage of utilities were not covering their costs than EPA's study concluded, we defined local sources of revenue more broadly than EPA and included some categories, such as interest earnings and reserve payments, that were used by large percentages of utilities. EPA has not done a similar analysis of wastewater utilities.

While our survey shows that, for an overwhelming majority of utilities, locally generated funds met or exceeded their operation and maintenance costs, it provides some indications that utilities' costs may be lower than they should be to adequately maintain facilities and equipment. Specifically, we looked at the extent to which utilities that were covering their operation and maintenance costs also deferred maintenance "because available funding was not sufficient." We found that for both drinking water and wastewater utilities, an estimated 29 percent of the utilities that covered their costs also deferred maintenance in their most recently completed fiscal year. However, there was no statistical difference in the extent to which the utilities deferred maintenance, whether they covered their operation and maintenance costs or not.

The fact that utilities were deferring maintenance suggests that either unanticipated expenses forced the utilities to reschedule planned maintenance or their budgets were never sufficient to cover the needed expenses in the first place. According to EPA and water industry experts, deferring maintenance beyond the optimal point for system repair and renewal can lead to earlier capital replacement needs and increases in the cost of providing service.

[9] *National Characteristics of Drinking Water Systems Serving Populations Under 10,000*, p. 4-1. EPA compared the financial characteristics of small systems and larger ones, in this instance, by dividing operating revenues by operation and maintenance expenses and deriving an "operating ratio" as a measure of financial health. Generally, an operating ratio below 1 is considered to be an indicator of weak financial health.

User Charges Represented a Major Source of Local Funds, but Were Increased Two Times or Fewer by Half of the Utilities

User charges represent a major source of locally generated funding at both drinking water and wastewater utilities. According to our survey, for about half of the utilities, user charges accounted for at least 90 percent of their local funds in their most recently completed fiscal year.[10] User charges accounted for at least three-quarters of the funds from local sources at an estimated 80 percent of the drinking water utilities and about 75 percent of the wastewater utilities.

We analyzed the data on utilities' user charges to determine if the utilities' ability to cover their cost of providing service was related to the frequency of their rate increases. As noted earlier, our survey-based estimates are that 29 percent of drinking water utilities and 41 percent of wastewater utilities had revenues from user charges and other local sources that were less than their cost of providing service. As table 2 shows, we found that more than half of these utilities reported raising their rates infrequently—once, twice, or not at all—during the 10-year period from 1992 to 2001. However, overall we found no statistically significant differences in the frequency of rate increases between the utilities that did not cover their costs and those that did.

We did not ask utilities to provide information on the magnitude of their rate increases. Some utilities may have a strategy of seeking fewer but larger rate increases. This strategy could enable them to cover more of their costs if the rate increases, though infrequent, are sufficiently large.

[10]About 21 percent of the drinking water utilities and 23 percent of the wastewater utilities indicated that they had local sources of funding in addition to user charges, but they did not report an amount. We have no way of knowing whether the amounts these utilities reported as user charges actually represented revenues from all local sources or from user charges alone. We excluded these utilities when we calculated the percentage of locally generated funding represented by user charges.

Table 2: Relationship between the Frequency of Rate Increases and Utilities' Ability to Cover Their Cost of Providing Service Using Revenues from All Local Sources, 1992–2001

	Estimated percentage of utilities that increased rates, by frequency of increase			
	Drinking water		Wastewater	
Number of rate increases	Did not cover cost of providing service	Covered cost of providing service	Did not cover cost of providing service	Covered cost of providing service
0	11	7	15	13
1-2	41	44	37	38
3-4	21	22	23	19
5-7	19	17	17	18
8-10	9	9	8	11

Source: GAO's analysis of survey data.

Other studies provide some data on the magnitude and frequency of rate increases by water utilities. In its July 1999 report on the characteristics of small drinking water systems, EPA examined the frequency and magnitude of rate increases and found that for larger systems (those serving more than 10,000 people), about 2-½ years had elapsed, on average, since the last increase.[11] In addition, EPA reported that the average size of the increase was 14 percent. Similarly, data collected by the Association of Metropolitan Sewerage Agencies for its 1999 financial survey indicated that the current rates had been in effect for an average of about 2-½ years. This survey also found that the sewer rates had increased 9 percent annually, on average, between 1996 and 1999.[12]

We further analyzed our survey data to determine if the frequency of rate increases varied depending on the utilities' size. We found that larger utilities, particularly those serving more than 100,000 people, were more likely to have had 5 to 10 rate increases from 1992 to 2001 than smaller

[11] *National Characteristics of Drinking Water Systems Serving Populations Under 10,000*, p. 4-8.

[12] Association of Metropolitan Sewerage Agencies, *AMSA 1999 Financial* Survey*: A National Survey of Municipal Wastewater Management Financing Trends* (1999), pp. 13, 65. The survey included 119 utilities serving populations greater than 21,000. Of the 93 utilities that provided information on how long current rates had been in effect, 45 reported that their rates had been in effect for less than 1 year prior to the survey; the longest period of time that a rate was unchanged was 17 years.

utilities. Conversely, smaller utilities were more likely than larger ones to have increased their rates infrequently during the 10-year period. Table 3 summarizes the results of our analysis.

Table 3: Frequency of Rate Increases, 1992 through 2001, by Size of Population Served

Frequency of rate increases, by population served	Estimated percentage of utilities that increased rates, by frequency	
	Drinking water utilities	Wastewater utilities
No increases		
10,001-25,000	8	15
25,001-50,000	12	14
50,001-100,000	7	17
Over 100,000	6	13
1-2 increases		
10,001-25,000	51	41
25,001-50,000	44	44
50,001-100,000	36	32
Over 100,000	27	23
3-4 increases		
10,001-25,000	19	22
25,001-50,000	24	21
50,001-100,000	25	21
Over 100,000	23	17
5-7 increases		
10,001-25,000	16	16
25,001-50,000	14	13
50,001-100,000	22	18
Over 100,000	24	29
8-10 increases		
10,001-25,000	6	7
25,001-50,000	6	9
50,001-100,000	10	11
Over 100,000	21	18

Source: GAO's analysis of survey data.

When we analyzed the data according to the utilities' ownership type, we found no statistical differences in the frequency of rate increases at drinking water utilities, whether they were public or privately owned.

Chapter 3: Many Utilities Lacked Comprehensive Asset Management Plans, but Most Had Identified Future Capital Needs

According to our survey, more than one out of four utilities lacked plans recommended by utility associations for managing their existing capital assets. Further, over half of the utilities with plans did not cover all their assets or omitted key plan elements, such as an assessment of the assets' physical condition. In addition, while most utilities had a preventive rehabilitation and replacement program, for about 60 percent of the drinking water utilities and 65 percent of the wastewater utilities, the actual rate of pipeline rehabilitation and replacement in recent years was less than their desired levels. Further, in their most recent fiscal year, an estimated one-third of the utilities deferred maintenance; one-third deferred major capital improvements; and one-third deferred minor capital improvements.

Our survey indicates that about 90 percent of the utilities had capital improvement plans that identify future needs and that about the same percentage of utilities reviewed their capital improvement needs annually whether or not a formal plan was in place. Utilities' capital improvement plans generally had a long-term focus—the large majority covered 5 years or more—as recommended by industry associations. Most utilities also had plans for financing their future capital needs, but an estimated 45 percent believed that their projected funding over the next 5 to 10 years would not be sufficient to meet the needs.

Many Utilities Lacked Comprehensive Asset Management Plans

According to our survey, more than 25 percent of drinking water and wastewater utilities lacked asset management plans, although some were in the process of developing such plans. Of the utilities with plans, more than half did not include all of their assets or omitted key plan elements.

Drinking water and wastewater utilities manage their existing capital assets to maximize the useful life of the assets, control operating costs, and generally enhance the efficiency of their operations. According to a comprehensive industry handbook, published in 2001, the term "asset management" means managing infrastructure-related assets, such as pipelines and equipment, to minimize the total cost of owning and operating them while maintaining adequate service to customers.[1] The

[1]The Association of Metropolitan Sewerage Agencies developed the handbook, *Managing Public Infrastructure Assets to Minimize Cost and Maximize Performance*, in partnership with the Association of Metropolitan Water Agencies, the American Water Works Association, and the Water Environment Federation, to help water and wastewater utilities adopt advanced management methods that can reduce long-term costs and improve service to customers.

handbook states that asset management allows an organization to characterize the condition of capital assets and quantify an ongoing renewal program to maximize their reliability. The handbook further provides that a goal of an asset management system should be "the ability to merge what is known about an organization's capital assets with rehabilitation standards and costs and with risk assessments of asset failures to identify critical assets."[2]

For the purposes of our survey, we focused on four areas identified as key elements of good asset management systems: an inventory of the assets, assessment criteria, the assets' condition, and the planned and actual expenditures to maintain the assets.[3] More specifically, we asked drinking water and wastewater utilities (1) if they had plans for managing their existing capital assets and (2) if so, whether these plans included a complete assessment of the physical condition of all capital assets, descriptions of the criteria used to measure and report on the condition of the assets, the condition level at which the assets will be maintained, and a comparison of the planned and actual dollar amounts used to maintain the assets at the established condition level. For each of the key elements, we also asked if the plans covered all or some capital assets or did not address the element at all.

Some Utilities Did Not Have Plans

Based on the results of our survey, a significant percentage of drinking water and wastewater utilities—an estimated 27 percent and 31 percent, respectively—did not have plans for managing their existing capital assets. However, 40 percent of the drinking water utilities and about 50 percent of the wastewater utilities were developing such plans at the time of our survey.

[2]*Managing Public Infrastructure Assets to Minimize Cost and Maximize Performance*, p. 154.

[3]We focused on elements of an asset management system identified by the Governmental Accounting Standards Board in a June 30, 1999, statement that made comprehensive changes in state and local governments' financial reporting. Among other things, it requires, for the first time, the governments to report information about public infrastructure assets, including their drinking water and wastewater facilities. Specifically, the governments must begin reporting depreciation of their capital assets or implement an asset management system. See *Governmental Accounting Standards Board Statement No. 34, Basic Financial Statements—and Management's Discussion and Analysis—for State and Local Governments.*

When we looked at the characteristics of the utilities without asset management plans, for the most part, we found no statistical differences between utilities of different sizes for either drinking water or wastewater utilities, with one exception: about twice as many of the smallest drinking water utilities—those serving populations of 10,001 to 25,000—lacked plans compared with the largest ones, serving populations of over 100,000 (the estimates were 34 percent and 17 percent, respectively). We also found that public drinking water utilities were somewhat more likely than their privately owned counterparts not to have plans for managing their existing capital assets (an estimated 29 percent compared with 11 percent).

Many Utilities' Plans Did Not Cover All Assets or Lacked Key Elements

According to our survey, more than two-thirds of the utilities had asset management plans—an estimated 69 percent of the drinking water utilities and 65 percent of the wastewater utilities—but many of the plans did not cover all of the utilities' assets or did not contain one or more key elements.[4] Table 4 summarizes the extent of coverage of utilities' assets and the four key elements in utilities' asset management plans.

[4]Three percent of drinking water utilities and 4 percent of wastewater utilities did not indicate that they did or did not have a plan.

Table 4: Extent to Which Utilities' Asset Management Plans Covered Assets and Key Elements

Plan element	Estimated percentage of plan coverage: Drinking water utilities		Estimated percentage of plan coverage: Wastewater utilities	
Complete assessment of the physical condition of the utility's capital assets	All assets	41	All assets	38
	Some assets	53	Some assets	54
	Not addressed in plan	6	Not addressed in plan	7
Descriptions of the criteria used to measure and report the assets' condition	All assets	30	All assets	26
	Some assets	53	Some assets	51
	Not addressed in plan	17	Not addressed in plan	23
Condition level at which utility intends to maintain the assets	All assets	34	All assets	25
	Some assets	50	Some assets	54
	Not addressed in plan	16	Not addressed in plan	21
Comparison of the planned and actual dollar amounts used to maintain the assets at the condition level established by the utility	All assets	28	All assets	22
	Some assets	40	Some assets	41
	Not addressed in plan	32	Not addressed in plan	36

Note: Numbers are estimated percentages of all utilities that have plans.

Source: GAO's analysis based on survey data.

Significantly, our survey results indicate that over 50 percent of utilities' asset management plans did not cover all assets. Industry associations for both drinking water and wastewater utilities advocate the inclusion of all capital assets in such plans. They also believe that good asset management planning starts with a comprehensive inventory of existing assets and encompasses other elements addressed in our survey as well. In fact, the comprehensive industry handbook cited earlier indicates that an integrated asset management system includes, among other things, a maintenance management system as well as components designed to inventory and analyze the condition of a utility's assets.[5] Using this information, utilities can optimize decisions on what system components require maintenance or need to be rehabilitated or replaced, when these actions need to occur, and what they will cost.

To minimize the reporting burden on utilities, we did not ask the surveyed utilities to be more explicit about the types of assets that were or were not covered by the plans. However, some evidence suggests that utilities might not be developing comprehensive plans for the management of their pipelines, a potentially critical omission considering that pipelines account for about 75 percent of the nation's investment in drinking water and wastewater infrastructure. A study sponsored by the American Water Works Association Research Foundation concluded that effective planning for pipeline rehabilitation and replacement falls into three categories: (1) developing asset inventory data on pipe condition by segment, (2) developing priorities for annual replacement plans, and (3) developing long-term plans to optimize the rate of replacement.[6] However, the report states that 15 of the 18 utilities reviewed for the study had not developed comprehensive information projecting their pipeline replacement needs based on when the pipes were installed and how long they are expected to last.

[5] *Managing Public Infrastructure Assets to Minimize Cost and Maximize Performance*, pp. 156-157.

[6] American Water Works Association Research Foundation, *Financial and Economic Optimization of Water Main Replacement Programs* (Denver, Colo.: 2001). This study included 18 utilities—13 in the United States, 2 in Canada, and 3 in Australia. The objective of the study was to identify and document best practices in planning for the rehabilitation and replacement of aging, deteriorated water main piping.

For utilities with plans, we analyzed our survey data according to the size of the utility. We found no statistical differences among utilities of different sizes with regard to the inclusion or exclusion of any of the four key elements in their asset management plans. However, when we similarly analyzed the data according to the type of utility ownership, we found that the asset management plans developed by privately owned drinking water utilities tended to be more comprehensive than those developed by publicly owned utilities. For example, we found that an estimated

- 55 percent of private utilities' plans covered all capital assets, compared with 40 percent of public utilities;
- 46 percent of private utilities' plans included criteria for all assets, compared with 28 percent for public utilities;
- 43 percent of private utilities' plans included the condition level at which the assets would be maintained, compared with 33 percent for public utilities; and
- 40 percent of private utilities' plans included a comparison of the planned and actual expenditures for maintaining the assets, compared with 26 percent for public utilities.

Despite Pipelines in Poor Condition, Some Utilities Had Deferred Maintenance, Capital Improvements, or Both

According to our survey results, some utilities had significant portions of pipelines in poor condition; for example, more than one-third of utilities had 20 percent or more of their pipelines nearing the end of their useful life. We also found that for an estimated 60 percent of drinking water utilities and 65 percent of wastewater utilities, the actual levels of pipeline rehabilitation and replacement in recent years were less than the utilities' desired levels. Further, in each of three categories—maintenance, minor capital improvements, and major capital improvements—an estimated one-third or so of utilities had deferred expenditures in their most recent fiscal year, and 20 percent had deferred expenditures in all three categories.

Drinking water and wastewater utilities carry out various activities to ensure efficient and cost-effective operations and plan for needed improvements. According to the industry handbook, for example, utilities carry out planned maintenance of plant, equipment, and pipes to prevent, minimize, or delay failures or shutdowns that result in unplanned maintenance activities and increased costs.[7] Utility officials told us that they also rehabilitate existing assets, such as pipelines, to extend their useful life. Both regular maintenance and rehabilitation of key assets help utilities keep their operating costs as low as possible. When maintenance and asset rehabilitation are no longer cost-effective options and capital assets reach the end of their useful life, they must be replaced, often requiring large investments. Despite their needs, utilities may have to postpone capital improvements because revenues are not sufficient to finance the costs or more immediate needs divert resources away from the planned improvements. However, deferring major or minor capital improvements can ultimately result in higher costs to the utilities. For example, additional costs may be incurred to repair damage associated with the failure of a major asset that was not replaced when planned.

Some Utilities Had Pipelines in Poor Condition and Rehabilitation and Replacement Rates That Were Less Than Desired

In looking at how utilities were managing their existing capital assets, we decided to focus on utilities' pipelines for several reasons. First, as noted earlier, EPA estimates that underground pipelines account for about 75 percent of the nation's existing capital investment in drinking water and wastewater infrastructure. Moreover, aging pipelines—including the water supply, transmission, and distribution lines at drinking water utilities and the sanitary sewer lines and other underground systems at wastewater utilities—represent a significant share of the estimated future capital investment needs. In May 2001, the American Water Works Association, citing a "huge wave of aging pipe infrastructure," predicted significant increases in pipe break rates and repair costs over the next 30 years—even if utilities increase their investment in pipe replacement by several times over today's levels.[8] According to EPA's 1999 Drinking Water Infrastructure Needs Survey, the largest category of need is the installation and rehabilitation of transmission and distribution systems—accounting for $83.2 billion, or 55 percent of the needs projected through 2019. For wastewater systems, EPA's 1996 Clean Water Needs Survey projected infrastructure-related needs for wastewater systems of $128 billion through 2016. However, according to an EPA official, the needs survey estimate substantially underestimates the needs associated with the rehabilitation and replacement of the underground infrastructure because these needs are frequently not detected and therefore tend not to be

[7] *Managing Public Infrastructure Assets to Minimize Cost and Maximize Performance*, p. 80.

[8] *Dawn of the Replacement Era: Reinvesting in Drinking Water Infrastructure*, p. 13.

included in long-range capital plans. As a result, the national survey tends not to include these costs. However, EPA has developed a more comprehensive estimate that does include such needs. Although the new estimate has not yet been released, the official confirmed that at least half of the projected capital need for wastewater systems will be associated with the rehabilitation and replacement of the underground infrastructure.

Given the projected needs for rehabilitating and replacing drinking water and wastewater pipelines, we asked for more detailed information on their age and condition. Among other things, this enabled us to explore the relationship between the age and condition of utilities' pipelines and their rehabilitation/replacement activities.[9]

Age and Condition of Pipelines

For our survey, we asked the utilities to estimate the percentage of their pipelines that were installed during each 25-year period between 1900 and 2000, as well as prior to 1900 and from 2000 to the present. Our results indicate that, in general, for about a third of utilities, a significant portion of their pipelines is relatively new—50 percent or more was built since 1975. At the other end of the spectrum, for an estimated 5 percent of the utilities, a significant portion of their pipelines is quite old: 50 percent or more was built before 1925.

Also, according to our survey, significant portions of pipelines are in poor condition at some utilities. Specifically, we estimate that for more than one-third of utilities, 20 percent or more of their pipelines were nearing the end of their useful life; and for 1 in 10 utilities, 50 percent or more of their pipelines were nearing the end of their useful life.

By size and type of utility, our survey results indicate the following:

- Utilities with 20 percent or more of their pipelines in poor condition tended to be smaller. In the case of drinking water utilities, an estimated 35 percent of the systems serving 10,001 to 25,000 people and 41 percent of the systems serving 25,001 to 50,000 people fell into this category, compared with 24 percent of the largest systems (those serving over

[9]For wastewater utilities, the information on the condition of pipeline, and its rehabilitation and replacement, represents what the utilities reported for their sanitary sewer lines. Our survey also requested information on combined storm/sanitary sewer lines, but because only about 20 percent of the utilities reported having such lines, we did not include the information in our analysis.

100,000 people). Among wastewater utilities, the survey data indicate that 42 percent of the smallest (serving 10,001 to 25,000 people) have at least 20 percent of their pipelines in poor condition, compared with 24 percent of the largest systems. We found no statistically significant differences between utilities in other size categories.

- Wastewater utilities with 50 percent or more of their pipelines in poor condition also tended to be smaller. A somewhat larger percentage of the systems serving populations of 10,001 to 25,000 and 25,001 to 50,000 fell into this category than systems serving more than 100,000 people (an estimated 14 and 13 percent, respectively, compared with 3 percent). We found no statistical differences among the population size categories for drinking water utilities.
- There was no statistical difference between public and privately owned drinking water utilities in terms of the percentage of pipelines reported to be nearing the end of their useful life.

In exploring the relationship between age and condition of the pipelines, we found some indication that utilities with a preponderance of "newer" pipelines were less likely to have pipelines in poor condition. For example, according to our survey, among drinking water utilities that had built three-quarters or more of their pipelines since 1950, an estimated 47 percent of the utilities reported having 20 percent or more of their pipelines nearing the end of its useful life. In contrast, an estimated 72 percent of the utilities that reported having less than 20 percent of their pipelines in poor condition had a preponderance of newer pipelines. Our findings were similar with regard to wastewater utilities.

However, the relationship between pipeline age and condition was not consistent. Indeed, industry studies have found that older pipe typically has a longer life expectancy than pipe of more recent vintage because of the type of material used, manufacturing techniques, and other factors. In addition, technological advances in pipeline rehabilitation allow drinking water and wastewater utilities to extend the useful life of existing pipelines by installing special liners, injecting grout or epoxy, or using other techniques.

Finally, we found little or no relationship between the condition of utilities' pipelines and the frequency with which the utilities had raised their user rates during the 10-year period from 1992 to 2001. Utilities with higher percentages of pipelines nearing the end of their useful life did not increase rates with any greater or lesser frequency than utilities with smaller percentages of such pipelines.

Rehabilitation and Replacement Activities

While no industry benchmark exists for the optimal pace of pipeline rehabilitation and replacement that is applicable to all utilities, our survey shows that nearly two-thirds of utilities have fallen short of their desired pace of rehabilitation and replacement.

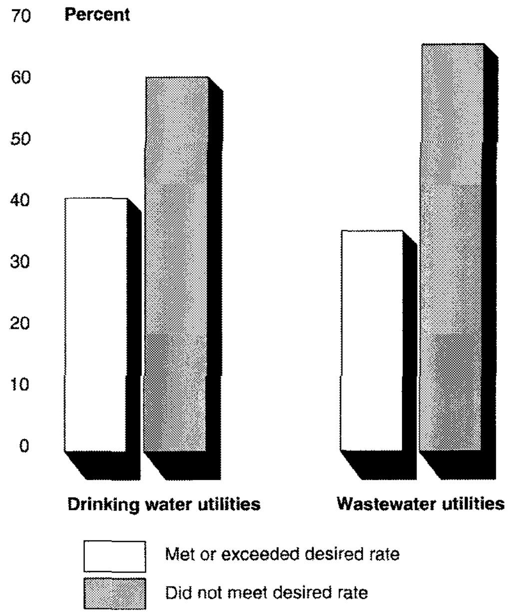
Little consensus exists among industry experts regarding what the appropriate rate of pipeline rehabilitation and replacement is for the average utility. Some experts have expressed concern that even though utilities may have kept up with the workload so far, the pace of pipeline upgrades will have to increase significantly because much of the existing pipeline is nearing the end of its useful life. For example, according to the industry report, *Dawn of the Replacement Era*, the United States is not so much faced with making up for an historical gap in the level of replacement funding, but it now has a compelling need to increase spending on pipeline replacement to prevent a serious funding gap from developing.[10] The report also points out that as pipes age, they tend to break more frequently, and utilities will be experiencing an estimated three-fold increase in pipeline repair costs at the same time replacement costs are rising. On the other hand, some experts believe that utilities are already facing a backlog of work. As the Water Environment Research Foundation reported in 2000, "years of reactive maintenance and minimal expenditures on sewers have left a huge backlog of repair and renewal work."[11]

While we could not compare our data to an industry benchmark because the optimal pace of pipeline rehabilitation and replacement is best determined on a utility-by-utility basis, we did examine the extent to which utilities were achieving what they had determined to be appropriate for their own circumstances. We found that many of them were falling short of their goals. As shown in figure 2, for many drinking water and wastewater utilities, a significant disparity exists between utilities' actual rehabilitation and replacement of pipelines and the rate at which they believe it should be occurring.

[10] *Dawn of the Replacement Era: Reinvesting in Drinking Water Infrastructure*, pp. 13-14.

[11] Water Environment Research Foundation, *New Pipes for Old: A Study of Recent Advances in Sewer Pipe Materials and Technology* (2000), p. 4-1.

Figure 2: Extent to Which Utilities' Actual Rate of Pipeline Rehabilitation and Replacement Met or Exceeded Their Desired Rate (on average, fiscal years 1998 through 2000)



Source: GAO's analysis of survey data.

Our survey indicates that roughly half of the utilities actually rehabilitated or replaced 1 percent or less of their pipelines annually, even though an estimated 89 percent of drinking water utilities and 76 percent of wastewater utilities believed that a higher level of rehabilitation and replacement should be occurring. More specifically, about 35 percent of drinking water utilities and 42 percent wastewater utilities believed that they should be annually rehabilitating or replacing more than 4 percent of their pipelines; yet, only an estimated 18 percent of these utilities were actually doing so. Table 5 shows in more detail how utilities' desired rates of rehabilitation and replacement compared with their average actual rates during recent fiscal years (1998 through 2000).

Table 5: Desired and Actual Rehabilitation and Replacement Rates for Pipelines (on average, for fiscal years 1998 through 2000)

Desired rate	Rate at which rehabilitation/replacement actually occurred					
	0 to 1 percent	>1 to 2 percent	>2 to 3 percent	>3 to 4 percent	> 4 percent	Total
Drinking water utilities						
0 to 1 percent	87	8	2	1	2	**100**
>1 to 2 percent	64	23	5	1	6	**100**
>2 to 3 percent	42	33	17	1	8	**100**
>3 to 4 percent	32	45	4	14	6	**100**
>4 percent	35	14	5	5	41	**100**
Wastewater utilities						
0 to 1 percent	85	8	1	1	4	**100**
>1 to 2 percent	47	40	7	4	3	**100**
>2 to 3 percent	51	23	18	2	6	**100**
>3 to 4 percent	35	39	10	4	12	**100**
>4 percent	28	23	7	6	36	**100**

Notes: In seeking information on utilities' desired and actual rehabilitation and replacement rates, we asked the survey respondents to provide separate answers for the percentage of pipeline subject to rehabilitation and the percentage subject to replacement, to the extent possible. For the purposes of this analysis, we added the percentages together to get combined rehabilitation and replacement rates. Totals may not add to 100 due to rounding.

Legend: Numbers are percentage of utilities within each category of desired rehabilitation/replacement rate. Shaded areas denote cases in which utilities' actual rehabilitation and replacement of pipelines was less than the utilities' desired rate.

Source: GAO's analysis of survey data.

For replacement rates alone, we found that about 60 percent of the drinking water utilities and 77 percent of the wastewater utilities replaced 1 percent or less of their pipelines annually, on average, from fiscal years 1998 through 2000.[12] At these rates, the utilities would need at least 100 years to replace their entire inventory of pipelines. These results are consistent with a 2001 study by the American Water Works Association Research Foundation, which reported that at least 9 of the 15 North American utilities examined in the study replaced their water mains at an annual rate ranging from 0.1 percent to 1 percent.[13] According to a

[12]As noted earlier, for wastewater utilities, the information on pipeline rehabilitation and replacement represents the information they reported for the sanitary sewer lines.

[13]American Water Works Association Research Foundation, *Financial and Economic Optimization of Water Main Replacement Programs* (Denver, Colo.: 2001), pp. 63–81. For some utilities, the actual replacement rate was unknown or not reported.

1994 Research Foundation study, an estimated 4,400 miles of pipeline, or 0.5 percent of the estimated 880,000 miles of existing pipeline, were being replaced annually.[14] The study concluded that utilities would replace any given pipe only once every 200 years at the estimated replacement rate and noted that no pipe has a 200-year life expectancy.

We also took a closer look at utilities with large percentages of pipelines nearing the end of their useful life. Specifically, we examined whether these utilities were any more or less likely than utilities with small percentages of pipelines nearing the end of their useful life to (1) have a preventive rehabilitation and replacement program or (2) achieve their desired rehabilitation and replacement rate for their pipelines. We found the following:

- Utilities with a large percentage of pipelines nearing the end of their useful life were no more likely to have a preventive rehabilitation and replacement program than utilities with a small percentage of pipelines nearing the end of their useful life.
- Utilities with larger percentages of pipelines nearing the end of their useful life were somewhat less likely to have achieved their desired rehabilitation and replacement rate. More specifically, a larger proportion of utilities with 20 percent or more of their pipelines nearing the end of their useful life did not achieve their desired rates than those with less than 20 percent of pipelines nearing the end of their useful life (the estimates were about 80 percent and about 50 percent of utilities, respectively). When we compared those having 50 percent or more of their pipelines nearing the end of their useful life with those having less than 50 percent nearing the end of their useful life, we found a similar difference.

Many Utilities Deferred Maintenance, Capital Improvements, or Both

We asked the surveyed utilities whether, in their most recent fiscal year, they had deferred maintenance, minor capital improvements, and/or major capital improvements as a result of insufficient funding. We found that about one-third of the utilities deferred maintenance expenditures and similar percentages of utilities deferred expenditures in the other categories.

[14] American Water Works Association Research Foundation, *An Assessment of Water Distribution Systems and Associated Research Needs* (Denver, Colo.: 1994), p. xv.

By size and type of ownership, we found the following:

- With one exception, there were no statistically significant differences among utilities of different sizes. However, the smallest drinking water utilities (serving populations of 10,001 to 25,000) were more likely to defer maintenance and major capital projects than utilities serving populations of 25,001 to 50,000—an estimated 35 percent compared with 24 percent for maintenance and an estimated 47 percent compared with 33 percent for major capital projects.
- Public drinking water utilities were more likely than their privately owned counterparts to defer maintenance (an estimated 31 percent compared with 12 percent) and major capital projects (42 percent compared with 26 percent).

About 20 percent of utilities had deferred expenditures in all three categories. Although we found no statistical differences among these utilities based on population size, we found that public drinking water utilities were more likely to defer all three than privately owned drinking water utilities (an estimated 21 percent compared with 7 percent).

Utilities that deferred expenditures in all three categories because available funding was not sufficient might also be expected to have other indications of financial problems. However, we found no statistically significant differences in the percentage of utilities that were unable to cover their cost of providing service through local sources of revenue, whether or not they deferred maintenance and capital improvements. Similarly, we found only one significant difference when we compared the frequency of rate increases among the utilities that deferred expenditures: wastewater utilities that had deferred expenditures in all three categories were somewhat more likely to have had frequent rate increases (8 to 10 rate increases from 1992 to 2001) than no increases during this period (an estimated 25 percent were in the first category, compared with 11 percent in the latter).[15]

[15]For the latter two analyses, we also compared utilities that deferred expenditures in all three areas with the utilities that had not deferred expenditures in any of the categories. We found no statistical differences in their ability to cover their cost of providing service or the frequency of their rate increases.

Most Utilities Had Capital Improvement Plans, but Many Questioned Adequacy of Future Funding

According to our survey, the large majority—about 90 percent—of utilities had capital improvement plans to identify future capital needs, and most also had plans for financing the projects identified. However, almost half of the utilities anticipated that their projected funding would not be sufficient to cover future needs over the next 5 to 10 years.

Utilities prepare capital improvement plans to identify future needs for plant and equipment as a result of the rehabilitation and replacement of existing infrastructure, compliance with regulatory requirements, and growth. According to EPA and industry sources, such plans should contain detailed information on all needed capital projects, the reasons for each project, and their estimated cost, for a specified period of time. Experts also agree that capital improvement plans should be updated on a regular basis to reflect changes in existing circumstances. The projected financing for needed capital projects should be identified and detailed in the utility's capital improvement plan, a separate financing plan, or some other document, and ideally, should reflect several alternative scenarios and their impact on user rates.

Most Utilities Had Capital Improvement Plans

Overall, our survey results indicate that about 90 percent of drinking water and wastewater utilities had capital improvement plans to identify future capital needs. The smallest systems, serving 10,001 to 25,000 people, were slightly less likely than larger systems to have had such plans (an estimated 86 percent for drinking water utilities and 81 percent for wastewater utilities). Also, the survey results show that about 90 percent of utilities reviewed their needs annually—whether or not they had developed formal plans.

Experts familiar with capital planning in the utility industry recommend that capital improvement plans have a longer-term focus and cover a 5- to 10-year period, at a minimum. The industry handbook developed by the Association of Metropolitan Sewerage Agencies recommends that utilities also forecast system replacement and expansion needs for a much longer period of time—even 50 to 100 years, if possible.[16] Our survey results indicate that about 95 percent of the utilities' capital improvement plans covered 5 years or more—with about 25 percent of drinking water

[16] *Managing Public Infrastructure Assets to Minimize Cost and Maximize Performance*, pp. 133-134.

utilities and about 20 percent of wastewater utilities covering 10 years or more. The remaining utilities had plans covering 4 years or less.

Most Utilities Had Plans for Financing Capital Needs, but Many Questioned Whether Funds Would Be Adequate

Most of the drinking water and wastewater utilities with capital improvement plans also had plans for financing the projects identified in their plans. According to our survey, 86 percent of the utilities had such plans, including virtually all of the largest utilities (those serving populations of over 100,000). Utilities with financing plans were somewhat more likely to dedicate a portion of their income to future capital needs. Specifically, our survey results indicate that about 73 percent of the drinking water utilities with plans considered future capital needs when developing their user rates by dedicating a portion of their income to future needs, while about 59 percent of the utilities without plans did so. In the case of wastewater utilities, an estimated 78 percent of the utilities with plans dedicated a portion of their income to future needs, while about 48 percent of those without plans did so.

According to our survey results, about 45 percent of the drinking water and wastewater utilities anticipated that their projected funding would not be sufficient to cover future needs over the next 5 to 10 years. The comprehensive industry handbook developed by the Association of Metropolitan Sewerage Agencies recommends that drinking water and wastewater utilities use a detailed financial planning window of at least 5 to 10 years to provide for future capital needs. However, the handbook notes that some utilities have a very narrow time line for financial planning; while such utilities may identify their future capital needs over a 5- to 10-year period, they only address detailed financial forecasting as part of their annual budget development process.

By utility size and type of ownership, we found the following:

- Drinking water utilities serving populations of 10,001 to 25,000 and 50,001 to 100,000 were more likely to believe that their projected revenues will be insufficient to cover anticipated future needs than the utilities serving over 100,000 people (an estimated 47 percent for the smaller population groups compared with 35 percent for the largest population group).
- There were no statistically significant differences among wastewater utilities of different sizes.
- Public drinking water utilities were somewhat more likely than privately owned systems to have concerns about future funding (an estimated 44 percent compared with 33 percent).

We also looked at the relationship between the extent to which utilities anticipated that their projected funding will be adequate to meet future needs and a number of other key variables related to funding. As table 6 shows, we found that both drinking water and wastewater utilities that anticipated that future funding will be inadequate were significantly more likely to have deferred maintenance, minor capital expenditures, or major capital expenditures in recent years compared with utilities that anticipated adequate future funding.

Table 6: Relationship between Adequacy of Projected Funding to Meet Needs Over the Next 5 to 10 Years and Other Key Variables Related to Funding

	Drinking water utilities		Wastewater utilities	
Key variables (percentage of utilities reporting in each category)	Anticipated funding would not be adequate to meet future needs	Anticipated funding would be adequate to meet future needs	Anticipated funding would not be adequate to meet future needs	Anticipated funding would be adequate to meet future needs
Deferred maintenance in most recently completed fiscal year	49	15	47	14
Deferred minor capital improvements in most recently completed fiscal year	53	20	50	20
Deferred major capital improvements in most recently completed fiscal year	63	24	57	20
Increased rates 1-2 times or not at all from1992 to 2001	53	51	54	50
Dedicated portion of income from user charges to future capital needs	66	71	65	76

Note: Numbers are estimated percentages of utilities that meet both row and column criteria.

Source: GAO's analysis of survey data.

Chapter 4: Profit Potential Is Key Factor in Private Companies' Decisions to Assume Operation or Ownership of Utilities

In making decisions to enter into privatization agreements with publicly owned utilities or the governmental entities they serve, the private companies we contacted primarily focus on a venture's potential to generate profits for the company. In assessing profit potential, the companies cited several specific criteria, such as the extent of opportunities to enhance operational efficiency, the utility's proximity to the companies' existing operations, and the potential for system growth. They also noted that state policies can influence privatization agreements. For example, two states that we contacted restrict the use of design-build-operate contracts, which give a single entity complete control over a project. Other states offer incentives to encourage the takeover of financially troubled public utilities.

Profit Potential Is Key Consideration for Private Companies

Privatization agreements range from contracts to operate and maintain drinking water or wastewater facilities to outright ownership by private entities. Regardless of the specific type of agreement, the companies we contacted all evaluate the potential for profits when considering entering into privatization agreements. Each of the five companies employs a somewhat different business strategy in its pursuit of privatization agreements, such as placing more emphasis on contract operations rather than on ownership of utilities or focusing on utilities of particular sizes or in particular locations. While none of the companies would consider entering into a privatization agreement without the potential to make a profit, differences in the companies' business strategies had some influence on the relative importance of the factors company officials cited as affecting profit potential.

Companies Engage in Different Types of Privatization Arrangements

Privatization can take different forms, ranging from contracting for specific services to selling the facilities to a private company. The most common form of privatization is contracting, which typically entails a competition among private bidders to perform certain activities. In the case of drinking water and wastewater utilities, such activities typically include operation and maintenance for a set period of time. When a municipality contracts with a private company for services, the government or public entity remains the financier and has management and policy control over the quality of services to be provided. According to an official at one of the largest companies we contacted, the most common type of public-private partnership in the field of drinking water and wastewater utilities has historically been operations and maintenance contracts covering from 1- to 5-year periods.

A variation of this type of contractual arrangement is called "design-build-operate," in which a private company (or a team of companies) designs, builds, and operates a facility under one agreement. Under this model, the local government retains ownership of the utility once it has been constructed and the contractor is responsible for operation and maintenance over the life of the contract, often a long-term agreement of 10 to 20 years.

In some instances, privatization involves transferring the ownership of utility assets from a municipality to the private sector. Once the assets have been sold, the municipality generally has no role in their financial support, management, or oversight. Collectively, the companies we contacted are involved in all of these types of privatization agreements.

Companies Cite Several Criteria for Evaluating Ventures' Profit Potential

According to officials of the five companies, criteria important to assessing the profitability of a proposed agreement to privatize a utility include the potential to improve the efficiency of the utility's operations; the proximity to the company's other utility operations; the potential for system growth; the terms of a proposed contract; and the potential need for capital investments. The relative importance of the factors varies, depending on the companies' business strategies.

All five of the companies saw the opportunity to improve the efficiency of a utility's operations as a key factor in evaluating candidates for privatization because of its potential impact on the companies' ability to make a profit. For example, in two cases, company officials said that operating efficiency can be improved by either reworking resources already in place (e.g., training workers or correcting inefficient practices) or investing in cost-effective improvements (e.g., computerizing operations or installing energy-efficient equipment). Officials in two other companies commented that the potential for correcting operational inefficiencies exists because public utilities often lack the financial or technical capabilities of companies that are in the business of assuming the operation or ownership of drinking water and wastewater utilities.

Officials of one company said that they focus on three major cost areas in looking for ways to increase efficiency: employees, energy, and chemicals. The officials acknowledged that dealing with employees can be sensitive because of concerns about potential job losses; thus, the savings in this area typically come about as a result of attrition or retraining. Energy consumption is a target of operational improvements because it accounts for about one-third of the average utility's operating costs. Because chemicals are also a major cost element, utilities can achieve significant savings through bulk purchases.

At drinking water utilities, another area with significant potential for cost savings is the reduction of "unaccounted for" water. This water represents the difference between the volume of water that leaves the treatment works and the volume that is "metered" (that is, used by customers according to their water meters). For example, utilities may experience leaks in their water distribution systems. According to an official of one of the largest companies we contacted, it is not uncommon for many communities to be unable to account for 25 percent or more of the water they produce.

The companies provided examples of the types of operational improvements that have resulted in cost savings or increased revenues:

- At a California drinking water utility, a company worked with state regulatory authorities to reduce the utility's requirements to monitor water quality, thus achieving over $200,000 savings in annual laboratory costs.
- At another utility, also in California, the company introduced improvements that reduced energy consumption by 13 percent and certain treatment costs by 22 percent.
- At a Georgia utility, the same company implemented a leak detection program that reduced unaccounted for water from 60 percent to 30 percent.
- Another company helped a Massachusetts wastewater utility to improve the treatment process and modify the utility's incinerator, which reduced incineration costs by about 75 percent.
- At a Texas drinking water utility, a meter replacement program is projected to increase water revenues by $1 million over 10 years.

Other criteria cited by the companies for evaluating profit potential of privatization opportunities include the following:

- **Proximity to the companies' existing operations**. Four of the five companies we contacted consider the utilities' proximity to their other operations when they decide whether or not to pursue a public-private partnership. In one case, company officials told us that their preference is to add new business in close proximity to existing operations because, among other things, the company's technical experts can make site visits at a reasonable cost. Officials from the other companies indicated that proximity to existing operations allows them to take advantage of economies of scale. For example, certain commonly used products and equipment such as chemicals, pipe, and meters can be purchased in bulk at lower costs and, with an expanded service area and customer base, the companies can spread the costs over more customers. An official from one of the companies commented that proximity is more of a consideration in the case of smaller utilities because they get more of a benefit than larger systems from sharing staff and other resources.

Increasing efficiency through economies of scale may be more difficult, however, in the case of relatively small and isolated utilities. According to an official of the National Association of Water Companies, a plan to consolidate several small, remote utilities probably would not be cost-effective where miles of pipelines were needed, for example, to connect the remote utilities. On the other hand, he noted that there are ways that privatization agreements with such utilities can be profitable. For example, private companies can bring in professional management expertise to oversee multiple utilities, use a limited number of system operators to run several small utilities that do not require full-time operators, and consolidate purchases of equipment and chemicals to get better prices.

- **Potential for system growth.** The projected growth in the population served by a utility—its customer base—was also mentioned as a factor by several companies. Officials from one company told us that projected population growth allows the company to increase its customer base and thus be assured of additional revenues. According to officials of another company, a utility's growth potential is more of a consideration when the privatization opportunity involves a smaller utility. The officials indicated that they examine this factor more closely at smaller utilities because these utilities may have to grow before they become profitable. According to an official of the National Rural Water Association, private companies generally consider public water systems serving rural, low-density populations an unattractive investment. Further, according to an official of the Kansas Rural Water Association, small towns often have relatively high water and sewer rates as well as a greater proportion of households with lower median incomes.[1]

[1]Testimony of Elmer Ronnebaum, General Manager of the Kansas Rural Water Association, before the Subcommittee on Fisheries, Wildlife, and Water, Senate Committee on Environment and Public Works, February 28, 2002.

- **Terms of operation and maintenance contracts.** Three of the companies told us that, in the case of operation and maintenance agreements, the length of time covered by a proposed contract is a key factor in their decisions. Generally, the longer the time period covered by the contract, the more time the company has to recoup its investment. According to an official at one of the largest companies we contacted, over the past 2 years the number of longer-term contracts has increased markedly, partly because of the increased use of design-build-operate contracts. The official also cited two examples of restrictive contract provisions that his company views as deal breakers. First, he said that some communities insist on unlimited liability guarantees from companies that bid on privatization contracts; however, responsible companies have to limit their liability. Second, restrictive maintenance provisions can impose a ceiling—typically $10,000—on a contractor's responsibility for maintenance items. According to the company official, this kind of restriction limits a company's ability to offer comprehensive solutions, which could be more cost-effective over the long term.

- **The potential need for capital investment.** The extent to which companies foresee a need to invest their funds to repair, replace, or upgrade utilities' plant and equipment can affect whether they enter into an agreement or what type of agreement they enter. Officials from several companies indicated that the condition of a utility's infrastructure is not a deterrent as long as the amount and nature of any investment needs are accurately reflected in the contract and the company is fairly compensated. One official commented that it is difficult to operate a utility as a contractor when the company has no control over the level of capital investment—and the level has not been adequate. In these situations, his company has tried to become more involved in developing capital improvement plans for the utilities they manage and to assume more responsibility for capital investments in general. The same official also commented that even if the condition of a utility's infrastructure is adequate, company officials may determine that a substantial investment will be required just to make the utility more efficient.

- **Other factors.** For drinking water utilities, officials of two companies noted the importance of a reliable water source. For example, according to one of the companies, an unreliable source limits profit potential because it can be costly to purchase water from other systems or develop a new source. For wastewater utilities, two companies pointed out that the presence of large quantities of industrial waste in the influent (the water flowing into the treatment facilities) can be a deterrent to an agreement. For example, one company official noted that industrial waste can increase treatment costs as well as pose a potential liability issue for the facility owner or operator.

States' Policies May Also Influence Companies' Decisions

In addition to identifying the site-specific factors they consider in evaluating privatization opportunities, representatives from all five of the companies we contacted also commented on state requirements or policies that can facilitate or impede privatization arrangements. We contacted officials of eight states identified by the five companies, EPA, and industry officials as having particular requirements or policies that affect privatization, either positively or negatively. Our contacts included representatives from the state agencies that oversee the drinking water and wastewater management programs and the public utility commissions, which regulate the rates and other activities of privately owned (and, in some cases, publicly owned) utilities. The state officials told us that their agencies are primarily interested in the delivery of adequate service to the public, whether the service is provided by publicly or privately owned utilities. However, the states have some requirements and policies that can affect companies' privatization decisions, including laws that address the acquisition of "troubled" utilities[2] and the use of design-build-operate contracts.

State regulators in Indiana and Pennsylvania have established programs that provide utilities in good standing with incentives to acquire or take over troubled utilities. For example, under Indiana's program, the acquiring utility is permitted to add an "acquisition adjustment" to its user rates as an incentive for taking over a troubled utility. Similarly, Pennsylvania's incentive program allows, under certain circumstances, the acquiring utility to increase the rate of return on its investment and thus, accelerate the recovery of costs incurred for needed system improvements. This program targets small utilities that lack the financial, managerial, and/or technical capacity to comply with applicable regulatory requirements. To encourage faster replacement of aging water distribution systems, Pennsylvania also established a special pipe surcharge program—the Distribution System Improvement Charge Program—in which companies make improvements to utilities' distribution systems. In return, the companies are allowed to raise rates by up to 5 percent without going through a formal hearing process.

[2]Under some state laws, either public or privately owned utilities may be the "acquiring utility; in other cases, state law specifies that the acquiring utility must be privately owned."

In addition to the incentive programs, four of the eight states we contacted—Connecticut, Indiana, New Jersey, and Pennsylvania—have enacted laws that give state regulators the authority to provide for qualified utilities to acquire or take over certain "troubled" utilities to resolve specific problems. For example, in New Jersey, the state may order the acquisition of small drinking water or wastewater utilities (with less than 1,000 connections) by a suitable public utility or a privately owned company if the small utilities fail to comply with an enforcement order. In New Jersey and the other states, the orders are directed at serious violations involving, for example, the availability, potability, or provision of water at adequate volume or pressure or the failure to remedy "severe deficiencies." While these laws could affect companies' privatization decisions by compelling the takeover of particular utilities, state officials indicated that the laws are rarely used.

Other state requirements or policies can affect the use of design-build-operate contracts, which couple the design and construction of new, expanded, or upgraded facilities with comprehensive agreements to operate and maintain the facilities. For example, Texas officials told us that professional services such as engineering design must be procured using a qualification-based selection while construction services must be procured using a bidding process. As a result, the design, construction, and operating services cannot be combined in a single procurement. The situation in Pennsylvania was similar; a state official told us that the state's procurement regulations have not been updated to allow the kind of combined procurement contemplated in a design-build-operate contract. In other instances, state laws can also facilitate the use of design-build-operate contracts. For example, Georgia amended its official code in 2000 to specifically authorize local governments to enter into contracts with private entities "for the design, construction, repair, reconditioning, replacement, maintenance, and operation of the system, or any combination of such services" at drinking water or wastewater systems.

We also identified certain requirements that could affect companies' privatization decisions and are specific to individual states. For example, New Jersey law requires that privatization proposals be approved by the applicable state agency. Among other things, state regulators assess the financial and technical capacity of the private company; the reasonableness of the contract terms; the extent to which the interests of utility customers are protected; and whether the particular contract terms, such as user charges and the status of current utility employees, are clearly spelled out. In addition, under California law, sales of drinking water and wastewater systems must be approved by voters in the affected community.

Appendix I: Survey of Drinking Water Utilities

United States General Accounting Office

Survey of Drinking Water Utilities

Introduction

The U.S. General Accounting Office (GAO) is an agency that assists the U.S. Congress in evaluating federal programs. In anticipation of analyzing a number of water infrastructure-related proposals this year, the Committee on Environment and Public Works, U. S. Senate, has asked GAO to collect information on user charges and infrastructure planning at both public and privately owned drinking water utilities.

Your utility has been randomly selected to receive this nationwide survey of drinking water utilities. As part of our study, we are asking for your help in completing this survey so that we can provide congressional decisionmakers with the information they need.

Part I of the survey collects general information on your utility. Part II collects information on funding from user charges and other sources. Part III collects information on your utility's infrastructure planning.

Instructions

When answering the questions in this questionnaire, please coordinate with the appropriate staff who have knowledge of your utility's user charges, other sources of funds, and capital improvement plans.

Please return your completed questionnaire in the enclosed, pre-addressed business reply envelope. If the envelope is misplaced, the return address is:

U.S. General Accounting Office
ATTN: Lisa Turner
441 G Street, NW - Room 2T23 A
Washington, DC 20548-0001

In testing this questionnaire, we found that it took some utilities less than an hour to complete and others about 2-3 hours.

If you have any questions about specific items in the questionnaire, call or e-mail your questions to:

- Lisa Turner at (202) 512-6559
  (e-mail address: turnerl@gao.gov); or
- Terri Dee at (202) 512-9592
  (e-mail address: deet@gao.gov).

Please provide the following information for the person we should contact if we have any follow-up questions:

Name: ______________________

Title: ______________________

Utility: ______________________

Phone #: (______) ______________________

E-mail: ______________________

n = number of utilities that responded to our survey.

1

Part I – General Information on the Utility

1. Does your utility have wholesale and/or resale customers (i.e., your utility bills other utilities for water or other services provided by you)? ***Do not include customers purchasing water or other services on an emergency basis.*** *(Please check one.)*
   n = 810
   1. [ ] Yes → ***continue to question 2*** **46.1%**
   2. [ ] No → ***skip to question 4*** **53.9%**

2. What was the estimated population served by your utility's wholesale and/or resale customers for your most recently completed fiscal year? *(Please check one.)*
   n = 386
   1. [ ] 10,000 or fewer **44.5%**
   2. [ ] 10,001 – 25,000 **24.4%**
   3. [ ] 25,001 – 50,000 **10.0%**
   4. [ ] 50,001 – 100,000 **9.7%**
   5. [ ] 100,001 – 500,000 **6.4%**
   6. [ ] 500,001 – 1,000,000 **1.2%**
   7. [ ] Over 1,000,000 **1.4%**
   8. [ ] Don't know **2.5%**

3. What is the number of wholesale or resale accounts that your utility served for your most recently completed fiscal year? *(Please insert number in the space provided.)*
   n = 379

   90.0% ≤ 30

4. Does your utility have retail customers (i.e., your utility bills residential, commercial, and/or industrial customers directly)?
   n = 819
   1. [ ] Yes → ***continue to question 5*** **98.7%**
   2. [ ] No → ***skip to question 7*** **1.3%**

5. What was the estimated population served by your retail operations for your most recently completed fiscal year? *(Please check one.)*
   n = 821
   1. [ ] 10,000 or fewer **0.0%**
   2. [ ] 10,001 – 25,000 **44.0%**
   3. [ ] 25,001 – 50,000 **28.2%**
   4. [ ] 50,001 – 100,000 **15.1%**
   5. [ ] 100,001 – 500,000 **10.2%**
   6. [ ] 500,001 – 1,000,000 **1.7%**
   7. [ ] Over 1,000,000 **0.9%**
   8. [ ] Don't know **0.0%**

6. What is the number of retail accounts that your utility served for your most recently completed fiscal year? *(Please indicate number in the space provided.)*
   n = 787

   90.0% ≤ 35,500

7. Which of the following services does your utility provide to its customers? *(Check all that apply.)*
   n = 821
   1. [ ] Source of supply **77.0%**
   2. [ ] Treatment **78.1%**
   3. [ ] Distribution and transmission (including storage tanks, booster stations, etc.) **97.9%**
   4. [ ] Contract operations **23.0%**
   5. [ ] Other *(Please explain.)* **5.5%**

__Definition for question 7__: Contract operations occur when one utility provides services to another utility. Such services could include treatment, distribution, billing, collection, etc.

2

8. What is the total length of the supply, transmission, and distribution lines owned by your utility for your most recently competed fiscal year? *(Please insert number in the space provided.)*
n = 792

90.1% ≤ 725 miles

9. What percentage (in physical terms – not cost) of your supply, transmission, and distribution lines were built in each of the following periods?

1. Pre 1900 **n = 418**	**90.1% ≤ 10** percent
2. 1900-24 **n = 478**	**92.1% ≤ 25** percent
3. 1925-49 **n = 577**	**89.2.% ≤ 38** percent
4. 1950-74 **n = 701**	**90.8% ≤ 60** percent
5. 1975-99 **n = 733**	**90.3% ≤ 79** percent
6. 2000-present **n = 686**	**91.3% ≤ 10** percent

10. Which one of the following best describes the ownership of your utility? *(Please check one.)*

Publicly owned by:

1. [ ] a municipal government **72.9%**
n = 821

2. [ ] a water district **11.4%**
n = 821

3. [ ] a water authority **8.3%**
n = 821

Privately owned by :

4. [ ] a for profit organization (e.g., investor-owned company) **4.7%**
n = 821

5. [ ] a not for profit organization (e.g., homeowners association) **2.8%**
n = 803

Other

6. [ ] other *(Please describe.)* **1.5%**
n = 821

11. Does your utility contract with a private entity to perform all or almost all services related to the management, operation, and maintenance of your drinking water system (i.e., the private entity provides full contract operations)? *(Please check one.)*
n = 818
1. [ ] Yes **3.8%**

2. [ ] No **96.3%**

12. Are any of your utility's activities regulated by a state utility commission? *(Please check one.)*
n = 815
1. [ ] Yes → ***continue to question 13*** **25.3%**

2. [ ] No **71.8%**
3. [ ] Don't know **2.9%**
→ ***skip to question 14***

13. Which of the following does your state utility commission regulate? *(Please check all that apply.)*

1. [ ] User rates **52.4%**
n = 242
2. [ ] Billing practices **47.0%**
n = 241
3. [ ] Notifications to customers **71.9%**
n = 242
4. [ ] Other *(Please describe.)* **32.6%**
n = 241

14. Does your utility also provide sewerage services? *(Please check one.)*
n = 815
1. [ ] Yes **69.0%**

2. [ ] No **31.0%**

3

Part II – Funding Sources for Drinking Water Utilities

15. In your most recently completed fiscal year, what were your utility's sources of funds? *(Please check all that apply.)*

n = 821

Utility and community sources

1. [ ] User charges **97.9%**
2. [ ] Property taxes **7.5%**
3. [ ] Sales to other utilities (e.g., water and other services) **41.6%**
4. [ ] Special operating cost levies (revenues from a specific user or group of users for a specific operating purpose, e.g., a large seasonal user such as a cannery) **3.1%**
5. [ ] Interest earned **77.1%**
6. [ ] Assessments **14.0%**
7. [ ] Permit and inspection fees **40.7%**
8. [ ] Hook-up, connection, or tap fees **88.9%**
9. [ ] Reserves **34.6%**
10. [ ] Other (e.g., fire hydrant maintenance fees, communication antenna leases, developer contributions, etc.) **51.0%**

Grant sources

11. [ ] Federal grants **15.5%**
12. [ ] State grants **20.6%**
13. [ ] Other grant sources **3.5%**

Debt and equity sources

14. [ ] Federal loans **11.5%**
15. [ ] State loans **25.4%**
16. [ ] Commercial loans **8.9%**
17. [ ] Revenue bond proceeds **35.7%**
18. [ ] General obligation bond proceeds **19.0%**
19. [ ] Private activity bond proceeds **1.5%**
20. [ ] Sale of stock **2.2%**
21. [ ] Other short-term debt instruments **7.9%**
22. [ ] Other long-term debt instruments **7.0%**
23. [ ] Other debt and equity sources **2.3%**

Other sources

24. [ ] Other (*Please describe.*) **8.6%**

4

16. This question refers to some of the funding sources that you may have checked in question 15. For your most recently completed fiscal year, approximately how much funding did your utility generate from user charges and other utility and community sources? *(Please insert the dollar amount in the space provided. If none, enter "0".)*

Funding source	Amount of funds generated
User charges *(item 1 in question 15)* **n = 738**	$
Utility and community sources, excluding user charges *(items 2 through 10 in question 15)* **n = 658**	$

17. Does your utility offer rate relief and/or some other type of subsidy for customers with lower incomes? *(Please check one.)*
n = 804
1. [ ] Yes **13.1%**
2. [ ] No **86.7%**

18. For your most recently completed fiscal year, approximately what were your utility's costs in the following categories? *(Please insert the dollar amount in the space provided. If none, enter "0".)*

1. Operations and maintenance $ ____________
n = 765
2. Capital expenditures $ ____________
n = 728
3. Debt service $ ____________
n = 714
4. Reserve payments $ ____________
n = 447
5. Depreciation expense $ ____________
n = 624
6. Total taxes $ ____________
n = 477
7. Other $ ____________
n = 312

Please describe other costs.

Definitions for question 18:

Operations and maintenance expenses are the day-to-day costs of providing your utility's services, including labor, board or council member fees, retirement system contributions, insurance premiums, energy, chemicals, supplies, replacement parts, repair services, fuel and other vehicle operating costs, communications services, any other utility service charges, permit fees, advertisements, public relations, travel and mileage expenses, training costs, reference materials, postage and delivery services, bad debt, legal services, engineering services, accounting services, laboratory services, etc.

Capital expenditures are costs of replacing capital assets that have reached the end of their useful lives, acquiring new assets that are intended to serve existing customers, and constructing new treatment plants and collection system components required to serve new areas or new users. Capital expenditures may include costs associated with materials, labor, architectural and/or engineering services, legal services, financial services, permit fees, etc.

Debt service expenses include the principal and interest paid on borrowed funds.

Reserve payments include revenues transferred to a reserve fund for paying future costs or as required by bond documents.

Depreciation expense is an amount deducted from revenue in determining income, based on an allocation of a long-lived asset's original cost over the years of its useful life.

5

Definition for question 19:

End of useful life may be determined by age of the lines, the type of material used in the lines, inspection, and history of line leakage and breakage.

Rehabilitation extends the life of lines through technologies such as microtunneling, sliplining, pipebursting, and form-in-place.

19. Does your utility have a preventive replacement and rehabilitation program for lines that are coming to the end of their useful life? **We are referring to preventive replacement and rehabilitation rather than replacement due to breakage.** *(Please check one.)*
    n = 807
    1. [ ] Yes → ***continue to question 20*** **59.1%**
    2. [ ] No → ***skip to question 21*** **40.9%**

20. In developing the current rates charged to users, did your utility include an amount to cover the cost of your utility's preventive replacement and rehabilitation program? **We are referring to preventive replacement and rehabilitation rather than replacement due to breakage.** *(Please check one.)*
    n = 492
    1. [ ] Yes **85.4%**
    2. [ ] No **12.8%**
    3. [ ] Not applicable, prohibited by public utility commission **1.9%**

21. Approximately what percentage of your utility's supply, transmission, and distribution lines are nearing the end of their useful life? *(Please indicate the percentage below. If none, enter "0".)*
    n = 766

    89.8% ≤ **49** percent

22. For your last three fiscal years (FY 1998 through FY 2000), on average, approximately what percentages of your supply, transmission, and distribution lines were replaced and rehabilitated annually? *(Please calculate the average percentages for fiscal years 1998 through 2000 and indicate the amounts below. If none, enter "0".)*
    1. **79.2%** ≤ **2** percent replaced annually
       n = 770
    2. **88.5%** ≤ **2** percent rehabilitated annually
       n = 617

23. Given the age of your utility's supply, transmission, and distribution lines, approximately what does your utility believe the annual rates of replacement and rehabilitation should be? *(Please enter percentage. If none, enter "0". If you cannot determine a separate rate for each, please provide a combined rate.)*
    1. **59.1%** ≤ **2** percent replacement rate
       n = 468
    2. **79.7%** ≤ **2** percent rehabilitation rate
       n = 300

       or
    3. **63.0%** ≤ **4** percent combined rate
       n = 470

24. In developing the current rates charged to users, does your utility dedicate a portion of its income each year to provide for future capital needs? *(Please check one.)*
    n = 807
    1. [ ] Yes → ***skip to question 26*** **69.6%**
    2. [ ] No → ***continue to question 25*** **28.6%**
    3. [ ] Not applicable, prohibited by public utility commission→***continue to question 25*** **1.8%**

6

25. Does a state or local law or regulation prohibit your utility from accumulating funds to provide for future capital needs? (*Please check one.*)
n = 243
1. [ ] Yes **12.0%**
2. [ ] No **75.2%**
3. [ ] Don't know **12.8%**

26. If your utility generates revenues in excess of costs, what happens to the excess revenues? *(Check all that apply.)*
n = 821
1. [ ] Retained in total by the utility for future use **73.9%**
2. [ ] Retained in part by the utility for future use **13.3%**
3. [ ] Transferred in total to the local government for activities related to the utility's operations (such as personnel or legal services) **0.9%**
4. [ ] Transferred in part to the local government for activities related to the utility's operations (such as personnel or legal services) **8.3%**
5. [ ] Transferred in total to the local government for activities not related to the utility's operations (such as construction of schools or roads) **1.8%**
6. [ ] Transferred in part to the local government for activities not related to the utility's operations (such as construction of schools or roads) **6.6%**
7. [ ] Paid out to investors as dividends **2.9%**
8. [ ] Refunded to customers when allowed rate of return is exceeded **1.3%**
9. [ ] Other *(Please explain.)* **2.5%**

Part III – Infrastructure Planning

27. Does your utility have a plan for managing its existing capital assets? *(Please check one.)*
n = 801
1. [ ] Yes → **skip *to question 29*** **69.4%**
2. [ ] No **27.3%** → ***continue to question 28***
3. [ ] Don't know **3.3%** → ***continue to question 28***

28. Is your utility currently developing a plan for managing its existing capital assets? *(Please check one.)*
n = 217
1. [ ] Yes **38.9%** → ***skip to question 30***
2. [ ] No **50.1%** → ***skip to question 30***
3. [ ] Don't know **11.0%** → ***skip to question 30***

7

29. Do your utility's plans for managing existing capital assets include the following components? *(Please check one for each of the following items.)*

   a. A complete assessment of the physical condition of the utility's capital assets
   n = 570
   1. [ ] Yes, for all capital assets **41.3%**
   2. [ ] Yes, for some capital assets **52.8%**
   3. [ ] No **5.9%**

   b. Descriptions of the criteria used to measure and report asset condition
   n = 559
   1. [ ] Yes, for all capital assets **29.5%**
   2. [ ] Yes, for some capital assets **52.9%**
   3. [ ] No **17.6%**

   c. The condition level at which your utility intends to maintain the assets
   n = 559
   1. [ ] Yes, for all capital assets **33.9%**
   2. [ ] Yes, for some capital assets **49.5%**
   3. [ ] No **16.6%**

   d. A comparison of the estimated and actual dollar amounts required to maintain the assets at the condition level established by your utility.
   n = 560
   1. [ ] Yes, for all capital assets **27.7%**
   2. [ ] Yes, for some capital assets **40.3%**
   3. [ ] No **32.0%**

Definition for question 30:

Capital improvement plan contains detailed information on all needed capital projects, the reason for each project, and their costs, for a specified period of time.

30. Does your utility have a plan that identifies future capital needs (i.e., a capital improvement plan)? *(Please check one.)*
   n = 810
   1. [ ] Yes → ***continue to question 31*** **91.1%**
   2. [ ] No **7.7%**
   3. [ ] Don't know **1.2%**

   } ***skip to question 33***

31. How many years does your utility's capital improvement plan cover? *(Please enter number of years in the space provided.)*
   n = 740

   93.7% ≥ 5 years

32. Does your utility have a plan for financing the capital projects identified in your capital improvement plan? *(Please check one.)*
   n = 750
   1. [ ] Yes **86.9%**
   2. [ ] No **13.1%**

33. How often does your utility review its capital improvement needs? *(Please check one.)*
   1. [ ] Annually **91.7%**
   n = 803
   2. [ ] Other *(Please indicate the time period in years.)* **8.3%**
   n = 58

   ______________ years

8

34. In which of the following years did your utility request rate increases? (*Please check all that apply.*)

1. [ ] 1992 **21.5%** **n = 814**
2. [ ] 1993 **22.4%** **n = 814**
3. [ ] 1994 **22.6%** **n = 814**
4. [ ] 1995 **22.4%** **n = 814**
5. [ ] 1996 **24.9%** **n = 814**
6. [ ] 1997 **23.6%** **n = 814**
7. [ ] 1998 **25.7%** **n = 814**
8. [ ] 1999 **25.7%** **n = 814**
9. [ ] 2000 **29.1%** **n = 814**
10. [ ] 2001 **30.6%** **n = 814**
11. [ ] No rate increases requested during this period **5.2%** **n = 814**
12. [ ] Not applicable; rate increases are not subject to external review and/or approval **17.6%** **n = 815**

35. In which of the following years did your utility increase rates? *(Please check all that apply.)*
n = 820

1. [ ] 1992 **27.2%**
2. [ ] 1993 **26.3%**
3. [ ] 1994 **29.5%**
4. [ ] 1995 **28.3%**
5. [ ] 1996 **32.1%**
6. [ ] 1997 **30.8%**
7. [ ] 1998 **34.0%**
8. [ ] 1999 **30.7%**
9. [ ] 2000 **35.1%**
10. [ ] 2001 **38.3%**
11. [ ] Did not increase rates during this period **6.0%**

36. In your most recently completed fiscal year, did your utility defer any maintenance because available funding was not sufficient? (*Please check one.*)
n = 813

1. [ ] Yes **30.0%**
2. [ ] No **70.0%**

37. In your most recently completed fiscal year, did your utility defer any minor capital improvements because available funding was not sufficient? (*Please check one.*)
n = 814

1. [ ] Yes **34.1%**
2. [ ] No **65.9%**

38. In your most recently completed fiscal year, did your utility defer any major capital projects because available funding was not sufficient? (Please check one.)
n = 810

1. [ ] Yes **40.6%**
2. [ ] No **59.4%**

39. Do you anticipate that, over the next 5 to 10 years, your utility's projected revenues and other funding will be sufficient to cover anticipated future needs? (Please check one.)
n = 807

1. [ ] Yes **57.0%**
2. [ ] No **43.0%**

9

40. If you have any additional comments on matters discussed in this survey or related to drinking water and wastewater infrastructure planning and funding, please use the space below or attach additional pages, if needed.

n = 821

Thank you for your help!

10

Appendix II: Survey of Wastewater Utilities

GAO
Accountability * Integrity * Reliability

United States General Accounting Office

Survey of Wastewater Utilities

Introduction

The U.S. General Accounting Office (GAO) is an agency that assists the U.S. Congress in evaluating federal programs. In anticipation of analyzing a number of water infrastructure related proposals this year, the Committee on Environment and Public Works, U. S. Senate, has asked GAO to collect information on user charges and infrastructure planning at both public and privately owned wastewater utilities.

Your utility has been selected to receive this nationwide survey of wastewater utilities. As part of our study, we are asking for your help in completing this survey so that we can provide congressional decisionmakers with the information they need.

Part I of the survey collects general information on your utility. Part II collects information on funding from user charges and other sources. Part III collects information on your utility's infrastructure planning.

Instructions

When answering the questions in this questionnaire, please coordinate with the appropriate staff who have knowledge of your utility's user charges, other sources of funds, and capital improvement plans.

Please return your completed questionnaire in the enclosed, pre-addressed business reply envelope. If the envelope is misplaced, the return address is:

U.S. General Accounting Office
ATTN: Lisa Turner
441 G Street, NW – Room 2T23 A
Washington, DC 20548-0001

In testing this questionnaire, we found that it took some utilities less than an hour to complete and others about 2-3 hours.

If you have any questions about specific items in the questionnaire, call or e-mail your questions to:

- Lisa Turner at (202) 512-6559
  (e-mail address: turnerl@gao.gov); or
- Terri Dee at (202) 512-9592
  (e-mail address: deet@gao.gov).

Please provide the following information for the person we should contact if we have any follow-up questions:

Name: ____________________

Title: ____________________

Utility: ____________________

Phone #: (______)____________

E-mail: ____________________

n= number of utilities that responded to our survey.

1

Part I – General Information on the Utility

1. Does your utility have wholesale customers (i.e., your utility bills other utilities for services provided by you)? *(Please check one.)* **n = 1,104**

   1. [ ] Yes → ***continue to question 2*** **40.3%**

   2. [ ] No → ***skip to question 4*** **59.8%**

2. What was the estimated population served by your utility's wholesale customers for your most recently completed fiscal year? *(Please check one.)* **n = 448**

   1. [ ] 10,000 or fewer **42.2%**

   2. [ ] 10,001 – 25,000 **20.6%**

   3. [ ] 25,001 – 50,000 **11.6%**

   4. [ ] 50,001 – 100,000 **14.5%**

   5. [ ] 100,001 – 500,000 **7.5%**

   6. [ ] 500,001 – 1,000,000 **1.4%**

   7. [ ] Over 1,000,000 **1.1%**

   8. [ ] Don't know **1.1%**

3. What is the number of wholesale accounts that your utility served for your most recently completed fiscal year? *(Please insert number in the space provided.)* **n = 437**

   90.3% ≤ 10

4. Does your utility have retail customers (i.e., your utility bills residential, commercial, and/or industrial customers directly)? *(Please check one.)* **n = 1,109**

   1. [ ] Yes → ***continue to question 5*** **94.2%**

   2. [ ] No → ***skip to question 7*** **5.8%**

5. What was the estimated population served by your retail operations for your most recently completed fiscal year? *(Please check one.)* **n = 1,113**

   1. [ ] 10,000 or fewer **0.0%**

   2. [ ] 10,001 – 25,000 **43.7%**

   3. [ ] 25,001 – 50,000 **24.0%**

   4. [ ] 50,001 – 100,000 **17.2%**

   5. [ ] 100,001 – 500,000 **11.2%**

   6. [ ] 500,001 – 1,000,000 **2.2%**

   7. [ ] Over 1,000,000 **1.6%**

   8. [ ] Don't know **0.0%**

6. What is the number of retail accounts that your utility served for your most recently completed fiscal year? *(Please indicate number in the space provided.)* **n = 974**

   90.0% ≤ 40,214

7. Which of the following services does your utility provide? *(Check all that apply.)* **n = 1,113**

   1. [ ] Collection system (including pump stations) **82.3%**

   2. [ ] Interceptor system (including pump stations) **70.9%**

   3. [ ] Treatment (include biosolids disposal) **93.8%**

   4. [ ] Reclaimed wastewater/effluent reuse **17.6%**

   5. [ ] Contract operations **17.3%**

   6. [ ] Other *(Please explain.)* **5.6%**

2

Definition for question 7: Contract operations occur when one utility provides services to another utility. Such services could include treatment, collection, billing, etc.

8. What is the total length of separate sanitary sewer lines owned by your utility for your most recently completed fiscal year? *(Please insert number in the space provided.)* **n = 1,079**

   90.1% ≤ 500 miles

9. What percentage (in physical terms – not cost) of your separate sanitary sewer lines were built in each of the following periods? *(Please enter percentages in spaces provided.)*

   1. Pre 1900 **n = 567** — **91.7% ≤ 10** percent
   2. 1900-24 **n = 672** — **90.9% ≤ 25** percent
   3. 1925-49 **n = 794** — **91.1% ≤ 40** percent
   4. 1950-74 **n = 934** — **91.1% ≤ 70** percent
   5. 1975-99 **n = 970** — **90.4% ≤ 75** percent
   6. 2000-present **n = 853** — **90.2% ≤ 10** percent

10. What is the total length of combined storm/sanitary sewer lines owned by your utility for your most recently completed fiscal year? *(Please insert number in the space provided.)* **n = 1,053**

    90.1% ≤ 67 miles

11. What percentage (in physical terms – not cost) of your combined storm/sanitary sewer lines were built in each of the following periods? *(Please enter percentages in spaces provided.)*

    1. Pre 1900 **n = 214** — **92.0% ≤ 30** percent
    2. 1900-24 **n = 234** — **89.7% ≤ 44** percent
    3. 1925-49 **n = 239** — **89.9% ≤ 60** percent
    4. 1950-74 **n = 263** — **91.2% ≤ 50** percent
    5. 1975-99 **n = 251** — **89.8% ≤ 36** percent
    6. 2000-present **n = 226** — **90.2% ≤ 5** percent

12. Which one of the following best describes the ownership of your utility? *(Please check one.)*

    Publicly owned by:

    1. [ ] a municipal government **76.8%** **n = 1,113**
    2. [ ] a sewer district **10.7%** **n = 1,113**
    3. [ ] a sewer authority **12.6%** **n = 1,113**

    Privately owned by:

    4. [ ] a for profit organization (e.g., investor-owned company) **0.1%** **n = 1,113**
    5. [ ] a not for profit organization (e.g., homeowners association) **0.5%** **n = 1,110**

    Other

    6. [ ] other *(Please describe.)* **1.4%** **n = 1,113**

3

13. Does your utility contract with a private entity to perform all or almost all services related to the management, operation, and maintenance of your wastewater system (i.e., the private entity provides full contract operations)? *(Please check one.)*
    n = 1,111
    1. [ ] Yes **6.1%**
    2. [ ] No **93.9%**

14. Are any of your utility's activities regulated by a state utility commission? *(Please check one.)*
    n = 1,103
    1. [ ] Yes → ***continue to question 15*** **13.6%**
    2. [ ] No **83.2%** → ***skip to question 16***
    3. [ ] Don't know **3.3%** → ***skip to question 16***

15. Which of the following does your state utility commission regulate? *(Please check all that apply.)*
    1. [ ] User rates **32.2%**
       n = 150
    2. [ ] Billing practices **23.2%**
       n = 150
    3. [ ] Notifications to customers **48.7%**
       n = 150
    4. [ ] Other *(Please describe.)***48.3%**
       n = 152

16. Does your utility also provide drinking water services? *(Please check one.)* **n = 1,097**
    1. [ ] Yes **58.8%**
    2. [ ] No **41.2%**

4

Part II – Funding Sources for Wastewater Utilities

17. *In your most recently completed fiscal year, what were your utility's sources of funds? (Please check all that apply.)* **n = 1,113**

Utility and community sources

1. [ ] User charges **96.9%**
2. [ ] Property taxes **10.3%**
3. [ ] Sales to other utilities (e.g., treatment and other services) **32.1%**
4. [ ] Product sales (e.g., reclaimed water, biosolids, fertilizer products, etc.) **12.3%**
5. [ ] Special operating cost levies (revenues from a specific user or group of users for a specific operating purpose, e.g., pretreatment charges for high strength waste) **38.6%**
6. [ ] Interest earned **78.2%**
7. [ ] Assessments **20.8%**
8. [ ] Permit and inspection fees **49.7%**
9. [ ] Hook-up or connection fees **77.8%**
10. [ ] Reserves **36.7%**
11. [ ] Other (e.g., developer contributions, etc.) **29.1%**

Grant sources

12. [ ] Federal grants **18.1%**
13. [ ] State grants **30.8%**
14. [ ] Other grant sources **3.5%**

Debt and equity sources

15. [ ] Federal loans **7.5%**
16. [ ] State loans **40.3%**
17. [ ] Commercial loans **6.4%**
18. [ ] Revenue bond proceeds **36.0%**
19. [ ] General obligation bond proceeds **22.6%**
20. [ ] Private activity bond proceeds **0.9%**
21. [ ] Sale of stock **0.0%**
22. [ ] Other short-term debt instruments **5.2%**
23. [ ] Other long-term debt instruments **3.1%**
24. [ ] Other debt and equity sources **1.4%**

Other sources

25. [ ] Other (*Please describe.*) **7.4%**

5

18. This question refers to some of the funding sources that you may have checked in question 17. For your most recently completed fiscal year, approximately how much funding did your utility generate from user charges and other utility and community sources? *(Please insert the dollar amount in the space provided. If none, enter "0".)*

Funding source	Amount of funds generated
User charges *(item 1 in question 17)* **n = 1,001**	$
Utility and community sources, excluding user charges *(items 2 through 11 in question 17)* **n = 872**	$

19. Does your utility offer rate relief and/or some other type of subsidy for customers with lower incomes? *(Please check one.)* **n = 1,071**

1. [ ] Yes **13.0%**
2. [ ] No **87.0%**

20. For your most recently completed fiscal year, approximately what were your utility's costs in the following categories? *(Please insert the dollar amount in the space provided. If none, enter "0".)*

1. Operations and maintenance $ ____________
n = 1,059
2. Capital expenditures $ ____________
n = 993
3. Debt service $ ____________
n = 983
4. Reserve payments $ ____________
n = 623
5. Depreciation expense $ ____________
n = 780
6. Total taxes $ ____________
n = 541
7. Other $ ____________
n = 435

Please describe other costs.

Definitions for question 20:

Operations and maintenance expenses are the day-to-day costs of providing your utility's services, including labor, board or council member fees, retirement system contributions, insurance premiums, energy, chemicals, supplies, replacement parts, repair services, fuel and other vehicle operating costs, communications services, any other utility service charges, permit fees, advertisements, public relations, travel and mileage expenses, training costs, reference materials, postage and delivery services, bad debt, legal services, engineering services, accounting services, laboratory services, etc.

Capital expenditures are costs of replacing capital assets that have reached the end of their useful lives, acquiring new assets that are intended to serve existing customers, and constructing new treatment plants and collection system components required to serve new areas or new users. Capital expenditures may include costs associated with materials, labor, architectural and/or engineering services, legal services, financial services, permit fees, etc.

Debt service expenses include the principal and interest paid on borrowed funds.

Reserve payments include revenues transferred to a reserve fund for paying future costs or as required by bond documents.

Depreciation expense is an amount deducted from revenue in determining income, based on an allocation of a long-lived asset's original cost over the years of its useful life.

6

Definition for question 21:

End of useful life may be determined by age of the lines, the type of material used in the lines, inspection, and history of line leakage and breakage.

Rehabilitation extends the life of lines through technologies such as microtunneling, sliplining, pipebursting, and form-in-place.

21. Does your utility have a preventive replacement and rehabilitation program for lines that are coming to the end of their useful life? **We are referring to preventive replacement and rehabilitation rather than replacement due to breakage.** (*Please check one.*)
    n = 1,091
    1. [ ] Yes → ***continue to question 22*** **56.2%**
    2. [ ] No → ***skip to question 23*** **43.8%**

22. In developing the current rates charged to users, did your utility include an amount to cover the cost of your utility's preventive replacement and rehabilitation program? (*Please check one.*)
    n = 613
    1. [ ] Yes **85.4%**
    2. [ ] No **14.0%**
    3. [ ] Not applicable, prohibited by public utility commission **0.7%**

23. Approximately what percentages (in physical terms—not cost) of your utility's separate sanitary sewer lines and combined storm/sanitary sewer lines are nearing the end of their useful life? *(Please indicate the percentage below. If none, enter "0".)*
    1. **89.0%** ≤ **47** % separate sanitary sewer lines **n = 980**
    2. **89.7%** ≤ **65** % combined storm/sanitary sewer lines **n = 312**

24. For your last three fiscal years (FY 1998 through FY 2000), on average, approximately what percentages (in physical terms—not cost) of your separate sanitary sewer lines and combined storm/sanitary sewer lines were replaced and rehabilitated annually? *(Please calculate the average percentages for fiscal years 1998 through 2000 and indicate the amount below. If none, enter "0".)*
    3. Separate sanitary sewer lines:
       a. **86.0%** ≤ **2** percent replaced annually **n = 974**
       b. **81.6%** ≤ **2** percent rehabilitated annually **n = 890**
    4. Combined storm/sanitary sewer lines:
       a. **87.8%** ≤ **2** percent replaced annually **n = 313**
       b. **91.2%** ≤ **2** percent rehabilitated annually **n = 307**

7

25. Given the ages of your utility's separate sanitary sewer lines and combined storm/sanitary sewer lines, approximately what does your utility believe the annual rates (in physical terms—not cost) of replacement and rehabilitation should be? *(Please enter percentage. If none, enter "0". If you cannot determine separate rates for replacement and rehabilitation, please provide a rate that combines both.)*

   a. Separate sanitary sewer lines:

      a. **65.8%** ≤ **2** percent replacement rate
      n = 559

      b. **56.3%** ≤ **2** percent rehabilitation rate
      n = 501

      or

      c. **64.8%** ≤ **4** percent combined rate
      n = 562

   b. Combined storm/sanitary sewer lines:

      a. **73.1%** ≤ 2 percent replacement rate
      n = 175

      b. **77.5%** ≤ **2** percent rehabilitation rate
      n = 160

      c. **66.3%** ≤ **4** percent combined rate
      n = 204

26. In developing the current rates charged to users, does your utility dedicate a portion of its income each year to provide for future capital needs? (*Please check one.*)
   n = 1,076
   1. [ ] Yes → ***skip to question 28*** **71.1%**
   2. [ ] No → ***continue to question 27*** **28.4%**
   3. [ ] Not applicable, prohibited by public utility commission→***continue to question 27*** **0.5%**

27. Does a state or local law or regulation prohibit your utility from accumulating funds to provide for future capital needs? (*Please check one.*)
   n = 316
   1. [ ] Yes **6.3%**
   2. [ ] No **76.6%**
   3. [ ] Don't know **17.1%**

28. If your utility generates revenues in excess of costs, what happens to the excess revenues? *(Check all that apply.)*
   n = 1,113
   1. [ ] Retained in total by the utility for future use **75.3%**
   2. [ ] Retained in part by the utility for future use **11.1%**
   3. [ ] Transferred in total to the local government for activities related to the utility's operations (such as personnel or legal services) **1.4%**
   4. [ ] Transferred in part to the local government for activities related to the utility's operations (such as personnel or legal services **10.0%**
   5. [ ] Transferred in total to the local government for activities not related to the utility's operations (such as construction of schools or roads) **1.1%**
   6. [ ] Transferred in part to the local government for activities not related to the utility's operations (such as construction of schools or roads) **4.8%**
   7. [ ] Paid out to investors as dividends **0.2%**
   8. [ ] Refunded to customers when allowed rate of return is exceeded **1.4%**
   9. [ ] Other *(Please explain)* **3.7%**

8

Part III – Infrastructure Planning

29. Does your utility have a plan for managing its existing capital assets? *(Please check one.)*
    n = 1,076
    1. [ ] Yes → **skip *to question 31* 65.4%**
    2. [ ] No **30.8%**
    3. [ ] Don't know **3.8%**

    (2–3) → ***continue to question 30***

30. Is your utility currently developing a plan for managing its existing capital assets? *(Please check one.)*
    n = 378
    1. [ ] Yes **47.4%**
    2. [ ] No **42.2%**
    3. [ ] Don't know **10.4%**

    (1–3) → ***skip to question 32***

31. Do your utility's plans for managing existing capital assets include the following components? *(Please check one for each of the following items.)*

    a. A complete assessment of the physical condition of the utility's capital assets
    n = 694
    1. [ ] Yes, for all capital assets **38.3%**
    2. [ ] Yes, for some capital assets **53.9%**
    3. [ ] No **7.8%**

    b. Descriptions of the criteria used to measure and report asset condition
    n = 682
    1. [ ] Yes, for all capital assets **25.3%**
    2. [ ] Yes, for some capital assets **51.3%**
    3. [ ] No **23.3%**

    c. The condition level at which your utility intends to maintain the assets
    n = 685
    1. [ ] Yes, for all capital assets **25.1%**
    2. [ ] Yes, for some capital assets **54.1%**
    3. [ ] No **20.8%**

    d. A comparison of the estimated and actual dollar amounts required to maintain the assets at the condition level established by your utility.
    n = 679
    1. [ ] Yes, for all capital assets **22.2%**
    2. [ ] Yes, for some capital assets **41.3%**
    3. [ ] No **36.5%**

9

Definition for question 32:

Capital improvement plan contains detailed information on all needed capital projects, the reason for each project, and their costs, for a specified period of time.

32. Does your utility have a plan that identifies future capital needs (i.e., a capital improvement plan)? *(Please check one.)*
n = 1,098
1. [ ] Yes → ***continue to question 33*** **87.5%**
2. [ ] No **11.6%** → ***skip to question 35***
3. [ ] Don't know **0.9%** → ***skip to question 35***

33. How many years does your utility's capital improvement plan cover? *(Please enter number of years in the space provided.)*
n = 943

95.4% ≥ **5** years

34. Does your utility have a plan for financing the capital projects identified in your capital improvement plan? *(Please check one.)*
n = 949
1. [ ] Yes **86.5%**
2. [ ] No **13.5%**

35. How often does your utility review its capital improvement needs? *(Please check one.)*
1. [ ] Annually **92.7%** **n = 1,078**
2. [ ] Other *(Please indicate the time period in years.)* **7.3%** **n = 78**
__________ years

36. In which of the following years did your utility request rate increases? *(Please check all that apply.)*

1. [ ] 1992 **22.7%** **n = 1,104**	6. [ ] 1997 **23.7%** **n = 1,104**
2. [ ] 1993 **21.1%** **n = 1,104**	7. [ ] 1998 **25.6%** **n = 1,104**
3. [ ] 1994 **24.3%** **n = 1,104**	8. [ ] 1999 **26.3%** **n = 1,104**
4. [ ] 1995 **22.0%** **n = 1,104**	9. [ ] 2000 **28.6%** **n = 1,104**
5. [ ] 1996 **23.5%** **n = 1,104**	10. [ ] 2001 **31.6%** **n = 1,104**

11. [ ] No rate increases requested during this period **8.1%**
n = 1,104
12. [ ] Not applicable; rate increases are not subject to external review and/or approval **16.2%** **n = 1,105**

37. In which of the following years did your utility increase rates? *(Please check all that apply.)*
n = 1,112

1. [ ] 1992 **27.4%**	6. [ ] 1997 **30.7%**
2. [ ] 1993 **26.8%**	7. [ ] 1998 **31.7%**
3. [ ] 1994 **29.8%**	8. [ ] 1999 **32.0%**
4. [ ] 1995 **27.0%**	9. [ ] 2000 **35.9%**
5. [ ] 1996 **29.8%**	10. [ ] 2001 **39.8%**

11. [ ] Did not increase rates during this period **9.9%**

38. In your most recently completed fiscal year, did your utility defer any maintenance because available funding was not sufficient? *(Please check one.)*
n = 1,098
1. [ ] Yes **28.6%**
2. [ ] No **71.4%**

10

39. In your most recently completed fiscal year, did your utility defer any minor capital improvements because available funding was not sufficient? (*Please check one.*)
n = 1,095
1. [ ] Yes **34.0%**
2. [ ] No **66.0%**

40. In your most recently completed fiscal year, did your utility defer any major capital projects because available funding was not sufficient? (*Please check one.*)
n = 1,099
1. [ ] Yes **36.3%**
2. [ ] No **63.7%**

41. Do you anticipate that, over the next 5 to 10 years, your utility's projected revenues and other funding will be sufficient to cover anticipated future needs? (*Please check one.*)
n = 1,085
1. [ ] Yes **56.1%**
2. [ ] No **43.9%**

42. If you have any additional comments on matters discussed in this survey or related to wastewater and drinking water infrastructure planning and funding, please use the space below or attach additional pages, if needed.
n = 1,113

Thank you for your help!

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Appendix III: GAO Contacts and Staff Acknowledgments

GAO Contacts

Ellen Crocker, (617) 565-7469
Lisa Turner, (202) 512-6559

Acknowledgments

In addition to the individuals named above, Wendy Ahmed, Mark Connolly, Teresa Dee, Laura Greene, Jerry Laudermilk, Grant Mallie, and Laura Shumway made key contributions to this report. Important contributions were also made by Ulana Bihun, Stuart Kaufman, Karen Keegan, Jonathan McMurray, Mehrzad Nadji, Carol Herrnstadt Shulman, and the staff in GAO's Shared Services Center.

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CRS Report for Congress

Water Infrastructure Needs and Investment: Review and Analysis of Key Issues

Updated November 24, 2008

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Prepared for Members and Committees of Congress

Congressional Research Service

Water Infrastructure Needs and Investment: Review and Analysis of Key Issues

Summary

Policymakers are giving increased attention to issues associated with financing and investing in the nation's drinking water and wastewater treatment systems, which take in water, treat it, and distribute it to households and other customers, and later collect, treat, and discharge water after use. The renewed attention is due to a combination of factors. These include financial impacts on communities of meeting existing and anticipated regulatory requirements, the need to repair and replace existing infrastructure, concerns about paying for security-related projects, and proposals to stimulate U.S. economic activity by building and rebuilding the nation's infrastructure.

The federal government has a long history of involvement with wastewater and drinking water systems, with the Environmental Protection Agency (EPA) having the most significant role, both in terms of regulation and funding. The U.S. Department of Agriculture also plays an important role in rural communities through its water and wastewater loan and grant programs. These programs have been popular; however, states, local communities, and others have asserted that various program gaps and limitations may be diminishing their potential effectiveness. They also point to the emergence of new infrastructure needs and issues.

A number of interest groups and coalitions have issued reports on infrastructure funding needs and related policy issues, as have EPA and the Congressional Budget Office (CBO). They present a range of estimates and scenarios of future investment costs and gaps between current spending and future costs. EPA and CBO, in particular, caution that projections of future costs are highly uncertain, and that funding gaps are not inevitable. Increased investment, sought by many stakeholders, is one way to shrink the spending gaps, but so, too, are other strategies such as asset management, more efficient pricing, and better technology.

Congressional interest in these issues has grown for some time and continued in the 110th Congress. In each of the past four Congresses, House and Senate committees acted on legislation to reauthorize and modify infrastructure financing programs in the Clean Water Act and Safe Drinking Water Act, but no bills were enacted. The Bush Administration has addressed water infrastructure in a number of general ways, but did not offer legislative proposals of its own. EPA's principal initiative has been to support strategies intended to ensure that infrastructure investment needs are met in an efficient, timely, and equitable manner.

This report identifies a number of issues that have received attention in connection with water infrastructure investment. It begins with a review of federal involvement, describes the debate about needs, and then examines key issues, including what is the nature of the problems to be solved; who will pay, and what is the federal role; and questions about mechanisms for delivering federal support, including state-by-state allotment of federal funds. Congressional and Administration activity on these issues from the 107th to the 110th Congresses also is reviewed.

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Water Infrastructure Needs and Investment: Review and Analysis of Key Issues

Introduction

Drinking water and wastewater treatment systems treat and safeguard the nation's water resources. Drinking water utilities have the task of supplying safe potable water to customers in both the proper quantity and quality. Wastewater utilities operate facilities that clean the flow of used water from a community. The federal government has had significant involvement with these systems for many years, both through setting standards to protect public health and the environment and through funding to assist them in meeting standards. While funding of water infrastructure programs has been addressed annually through the congressional appropriations process, authorizing legislation affecting policy and program issues was last enacted in 1996 (for drinking water infrastructure) and 1987 (for wastewater infrastructure).[1] More recently, water infrastructure issues have been receiving increased attention by policymakers and legislators. The renewed attention is due to a combination of several factors.

- **Meeting Regulatory Requirements.** Financial impacts of meeting regulatory requirements — some new, some long-standing — are a continuing issue for many communities. In the case of drinking water systems, the most pressing rules are new, either recently issued or pending, as the result of standard-setting by the Environmental Protection Agency (EPA) to implement the Safe Drinking Water Act Amendments of 1996. (Many of these rulemakings were initiated under amendments passed in 1986.) These rules impose new or stricter drinking water limits on numerous contaminants, including arsenic, radioactive contaminants, and microbials and disinfection byproducts, among others. For wastewater systems, principal regulatory requirements mandated by the Clean Water Act have not changed since 1972, and the majority of communities have achieved or are in the process of achieving compliance. The newer issue for wastewater systems is the cost of controls and practices to manage what are termed wet weather pollution problems, such as urban stormwater runoff and overflows from municipal sewers. These

[1] This report focuses on drinking water systems that take in water, treat it, monitor it, and distribute it to households and other customers, and wastewater systems that collect, treat, and typically discharge water after use. It does not address infrastructure related to water supply systems that generally are part of larger multi-purpose projects for irrigation, flood control, power supply and recreation that typically are built or assisted by the Bureau of Reclamation and the U.S. Army Corps of Engineers.

requirements are old in the sense that most wastewater utilities have not addressed long-standing wet weather problems, but they also are new because in many communities, specific measures are only now being identified.

- **Financing Infrastructure Repair or Replacement.** A more recent focus by stakeholders is on the need to repair and replace infrastructure that has been in place for decades and will soon fail, many believe. According to the American Water Works Association (AWWA), "We stand at the dawn of the replacement era ... replacement needs are large and on the way. There will be a growing conflict between the need to replace worn-out infrastructure and the need to invest in compliance with new regulatory standards."[2] Over the long term, these stakeholders say, a higher level of investment than is occurring today is required. For both wastewater and drinking water systems, a key concern is that EPA's funding programs, the largest sources of federal assistance, do not, in the main, support repair and replacement; their focus is upgrades and new construction needed to achieve wastewater and drinking water standards.

- **Security.** Beyond the traditional infrastructure needs related to regulatory compliance and system repair and expansion, the terrorist attacks of September 11, 2001, generated new investment needs for drinking water and wastewater systems. The national costs of addressing water and wastewater security needs have not been quantified; however, the AWWA estimated that municipal water systems would have to spend more than \$1.6 billion just to ensure control of access to critical water system assets.[3] This estimate does not include the capital costs of upgrades to address vulnerabilities that water system managers have identified in vulnerability assessments, or the costs facing wastewater systems and smaller drinking water systems. Although EPA has identified a range of security measures that are eligible for funding through traditional infrastructure assistance programs, competition already is severe for these funds, which are primarily used for projects needed to meet regulatory requirements.

- **Problems That Do Not Fit Existing Solutions.** For some, an interest in water infrastructure legislation derives from concern that traditional federal programs and financing approaches do not fit well with some current types of needs. Points at issue vary, but the common thread is that certain needs are not being well met by programmatic solutions that now exist. In some cases (metropolitan

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[2] American Water Works Association, *Dawn of the Replacement Era, Reinvesting in Drinking Water Infrastructure*, May 2001, p. 5. (Hereafter cited as AWWA Report.)

[3] American Water Works Association, *Protecting Our Water: Drinking Water Security in American After 9/11*, Executive Summary, 2003.

drinking water systems, for example), there is a perception that EPA's programs are more geared to aiding small systems than large ones. In other cases, the concern is how to fund types of projects that include mixed elements (e.g., developing new community water supplies and treating that water, especially in rural areas) that do not meet traditional program definitions, or are seemingly spread across jurisdictions of multiple federal agencies. Still others believe that expanding program eligibility to include water conservation projects could reduce overall needs for capital investment. Another concern arises in small, dispersed communities where on-site treatment systems may be preferable to centralized facilities; however on-site treatment generally is not eligible for federal aid. At issue for Congress is whether to modify existing programs to address such needs, or to address them in legislation individually and case-by-case.[4]

- **Other Legislative Models and Activity.** Legislative approaches for other types of infrastructure — especially surface transportation and aviation — have suggested possible models for water infrastructure financing. The federal highway and mass transit and aviation programs are supported by trust funds derived from fees and taxes paid by users of those systems and facilities. Some proponents of water infrastructure spending, concerned about a gap between needs and available funds, believe that an initiative based on a federal water trust fund would conceptually be a logical follow-on to the surface transportation and aviation programs. According to that view, passage of those measures could give momentum to enacting new budget authority for water infrastructure spending, as well. Still, differences are apparent, especially the fact that, unlike surface transportation and aviation, there is no comparable dedicated trust fund for water infrastructure, or easily identifiable revenue source for a trust fund. While surface transportation and aviation may offer ideas and momentum, they also may be imperfect models for water, unless dedicated revenue sources for a water trust fund can be identified.

- **Changed Dynamics at the Federal Level about "Who Should and Can Pay."** For many years, a focus on federal deficit reduction restrained the federal government from making major new investments in water infrastructure or other new programs. Early in this decade, forecasts of budgetary surplus encouraged a variety of interests to advocate increasing the federal commitment to water infrastructure. But, beginning in 2001, estimates of surplus changed to large federal deficits, especially associated with spending on the nation's heightened priorities of defense and homeland security

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[4] For background, see CRS Report RL30478, *Federally Supported Water Supply and Wastewater Treatment Programs*, by Betsy A. Cody, Claudia Copeland, Mary Tiemann, Nicole T. Carter and Jeffrey A. Zinn.

> following the September 11 terrorist attacks. By mid-2007, the Congressional Budget Office (CBO) and others observed that the federal budgetary situation was improving, but CBO cautioned that the United States continues to face severe long-term budgetary challenges. Throughout this period, the nation's fiscal environment has severely constrained arguments by proponents of greater federal investment and larger federal expenditures for water infrastructure. By mid-2008, conditions encouraging more federal investment in infrastructure facilities (water, transportation, and other types) appeared to emerge — not due to a strengthened U.S. economy, but rather as a result of a widespread economic slowdown, which led many to advocate infrastructure spending as one component of programs to stimulate economic activity and create jobs. While many academic and government studies have found that the impact of infrastructure spending on economic activity is modest and long in coming, pressure for economic stimulus has combined with the issues described above (and discussed in this report) to draw greater attention to infrastructure investment.

This report identifies a number of issues receiving attention in connection with water infrastructure. It begins with a brief review of federal involvement, describes the debate about funding needs, and then examines key issues, including what is the nature of the problems to be solved; who will pay, and what is the federal role; and questions about mechanisms for delivering federal support, including state-by-state allotment. Recent congressional and Administration activity on these issues also is reviewed.

Background: History of Federal Involvement

The federal government has a lengthy history of involvement with wastewater and drinking water systems. The history of financial assistance is longer for wastewater than for drinking water, however. EPA has the most significant role, both in terms of regulation and funding.

Wastewater

The Water Pollution Control Act of 1948 (P.L. 80-845) was the first comprehensive statement of federal interest in clean water programs. While it contained no federally required goals, limits, or even guidelines, it started the trickle of federal aid to municipal wastewater treatment authorities that grew in subsequent years. It established a grant program to assist localities with planning and design work, and authorized loans for treatment plant construction, capped at $250,000 or one-third of construction costs, whichever was less. With each successive statute in the 1950s and 1960s, federal assistance to municipal treatment agencies increased. A construction grant program replaced the loan program; the amount of authorized funding went up; the percentage of total costs covered by federal funds was raised; and the types of project costs deemed grant-eligible were expanded.

In the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500, popularly known as the Clean Water Act, 33 U.S.C. 1251 *et seq.*), Congress totally revised the existing federal clean water law, including with regard to wastewater systems. At the time, there was widespread recognition of water quality problems nationwide and frustration over the slow pace of industrial and municipal cleanup efforts under existing programs. In the 1972 law, Congress strengthened the federal role in clean water and established national standards for treatment, mandating that all publicly owned treatment works achieve a minimum of secondary treatment (defined in EPA regulations as removing 85% of incoming wastes), or more stringent treatment where necessary to meet local water quality standards, and set a July 1, 1977, deadline for meeting secondary treatment. A number of new conditions were attached to projects constructed with grants. In exchange, federal funds increased dramatically. The federal share was raised from 55% to 75%, and annual authorizations were $5 billion in FY1973, $6 billion in FY1974, and $7 billion in FY1975.

In 1977, the grant program was reauthorized through FY1982; annual authorizations were $5 billion for each of the last four years covered by that act (P.L. 95-217). Some restrictions were imposed, including requirements that states set aside a portion of funds for innovative and alternative technology projects and for projects in rural areas. In addition, the types of eligible projects were limited in order to focus use of federal funds on projects with environmental benefits in preference to projects aiding community growth. When the program was again reauthorized in 1981 (P.L. 97-117), Congress and the Administration agreed to significant restrictions, out of concern that the program's wide scope was not properly focused on key goals. Budgetary pressures and a desire to reduce federal spending also were concerns. Annual authorizations under this act were $2.4 billion, the federal share was reduced to 55%, and project eligibilities were limited further.

The 1972 law required a "needs survey" every two years to adjust the statutory allotment formula by which grant funds were divided among the states. In this survey, EPA compiles state data to estimate capital costs for water quality projects and other activities eligible for support under the Clean Water Act. From an initial estimate of $63 billion in 1973, the survey figure went to a high of $342 billion in 1974, dropped to $96 billion in 1976, rose to $106 billion in 1978, $120 billion in 1980, declined to $80 billion in 1990, was assessed at $139.5 billion in 1996, and rose to $181.2 billion in 2000, the most recent survey. Inconsistencies and variations have been ascribed to several factors, including the lack of precision with which needs for some project categories could be assessed (especially in the early years) and the desire of state estimators to use the needs survey as a way of keeping their share of the federal allotment as high as possible.[5] However, EPA believes that recent surveys produce credible data, because of the requirement that needs must be justified by project-specific documentation.

By the mid-1980s there was considerable policy debate between Congress and the Administration over the future of the construction grants program and, in

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[5] For discussion of several of these factors, see Water Pollution Control Federation (now, the Water Environment Federation), *The Clean Water Act with Amendments,* 1982, p. 14.

particular, the appropriate federal role. Through FY1984, Congress had appropriated nearly $41 billion under this program, representing the largest nonmilitary public works programs since the Interstate Highway System. The grants program was a target of the Reagan Administration's budget cutters, who sought to redirect budget priorities and establish what they viewed as the appropriate governmental roles in a number of domestic policy areas, including water pollution control. Thus, for budgetary reasons and the belief that the backlog of wastewater projects identified in 1972 had largely been completed, the Reagan Administration sought a phase-out of the act's construction grants program by 1990. Many states and localities, which continued to support the act's water quality goals and programs, did support the idea of phasing out the grants program, since many were critical of what they viewed as burdensome rules and regulations that accompanied the receipt of federal grant money. However, they sought a longer transition and ample flexibility to set up long-term financing to promote state and local self-sufficiency.

Congress's response to this debate was contained in 1987 amendments to the act (P.L. 100-4). It authorized $18 billion over a nine-year period for sewage treatment plant construction, through a combination of the traditional grant program and a new State Water Pollution Control Revolving Funds (SRF) program. Under the new program, federal capitalization grants would be provided as seed money for state-administered loans to build sewage treatment plants and, eventually, other water quality projects. Cities, in turn, would repay loans to the state, enabling a phaseout of federal involvement while the state built up a source of capital for future investments. Allotment of the SRF capitalization grants among states continues to be governed by a statutory formula, which Congress revised in 1987 (see discussion below, "Allotment of Funds"). Under the amendments, the SRF program was phased in beginning in FY1989 and entirely replaced the previous grant program in FY1991. The intention was that states would have greater flexibility to set priorities and administer funding, while federal aid would end after FY1994.

Municipalities have made substantial progress towards meeting the goals and requirements of the act, yet state water quality reports continue to indicate that discharges from wastewater treatment plants are a significant source of water quality impairments nationwide. In the 2000 National Water Quality Inventory report, states reported that municipal wastewater treatment plants contribute to water quality impairments of rivers, streams and lakes and are the most widespread source of pollution affecting estuarine waters. The authorizations provided in the 1987 amendments expired in FY1994, but pressure to extend federal funding has continued, in part because estimated needs remain so high. Thus, Congress has continued to appropriate funds, and the anticipated shift to full state responsibility has not yet occurred. Through FY2008, Congress has appropriated $78.3 billion in Clean Water Act assistance, including $26.2 billion in SRF capitalization grants.

Drinking Water

Public water systems are regulated under the Safe Drinking Water Act (SDWA) of 1974 (P.L. 93-523), as amended (42 U.S.C. 300f-300j). Congress enacted the SDWA after nationwide studies of community water systems revealed widespread water quality problems and health risks resulting from poor operating procedures, inadequate facilities, and uneven management of public water supplies in communities of all sizes. The 1974 law gave EPA substantial discretionary authority to regulate contaminants that occur in public drinking water supplies, and authorized EPA to delegate primary implementation and enforcement authority for the Public Water System Supervision program to the states.

SDWA drinking water regulations apply to more than 158,000 public water systems (both privately and publicly owned systems) that provide piped water for human consumption to at least 15 service connections or that regularly serve at least 25 people. Of these systems, 52,837 are community water systems (CWSs) that serve residential populations year-round. (Roughly 15% of community systems are investor-owned.) All federal regulations apply to these systems. More than 19,100 water systems are non-transient, non-community water systems (NTNCWSs), such as schools or factories, that have their own water supply and serve the same people for more than six months but not year-round. Most drinking water requirements apply to these systems.[6]

In contrast to the 40-plus years of federal support for financing municipal wastewater treatment facilities, Congress relatively recently, in 1996, established a program under SDWA to help public water systems finance projects needed to comply with federal drinking water regulations. Funding support for drinking water only occurred more recently for several reasons. Until the 1980s, the number of drinking water regulations was fairly small, and public water systems often did not need to make large investments in treatment technologies to meet those regulations. Relatedly, good quality drinking water traditionally had been available to many communities at relatively low cost. By comparison, essentially all communities have had to construct or upgrade sewage treatment facilities to meet the requirements of the 1972 Clean Water Act. In addition, when the SDWA was first enacted, few expected that the number of small, less economical water systems would continue to increase.

Over time, drinking water circumstances have changed as communities have grown, and commercial, industrial, agricultural, and residential land-uses have become more concentrated, thus resulting in more contaminants reaching drinking water sources. Moreover, as the number of federal drinking water standards and related monitoring requirements have increased, many communities have found that their water may not have been as good as once thought and that additional treatment was needed to meet the new standards and protect public health. From 1986 to 1996, for example, the number of regulated drinking water contaminants grew from 23 to 83. EPA and the states began expressing greater concern that many of the nation's community water systems (44,000, or 83% of all CWSs, of which were small) were likely to lack the financial capacity to meet the rising costs of complying with SDWA requirements.

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[6] Another 86,210 systems are transient non-community water systems (TNCWSs) (e.g., campgrounds and gas stations) that provide their own water to transitory customers. TNCWSs generally are required to comply only with regulations for contaminants that pose immediate health risks (such as microbial contaminants), with the proviso that systems that use surface water sources must also comply with filtration and disinfection regulations.

Congress responded to these concerns with the 1996 SDWA Amendments (P.L. 104-182), which established a drinking water state revolving loan fund (DWSRF) program to help public water systems finance projects needed to comply with SDWA regulations and to further the public health protection objectives of the act. This program, patterned after the Clean Water Act SRF, authorizes EPA to make grants to states to capitalize DWSRFs, which states then use to make loans to water systems. States are required to match 20% of their federal capitalization grant, and must make available 15% of their grant for loan assistance to small systems. Communities repay loans into the fund, thus making resources available for projects in other communities. Eligible projects include installation and replacement of treatment facilities, distribution systems, and certain storage facilities. Projects to replace aging infrastructure are eligible if they are needed to maintain compliance or to further public health protection goals.

Public water systems eligible to receive DWSRF assistance include community water systems (whether publicly or privately owned) and not-for-profit noncommunity water systems. The law generally prohibits states from providing DWSRF assistance to systems that lack the capacity to comply with the act or that are in significant noncompliance with SDWA requirements, unless these systems meet certain conditions to return to compliance. (Although the law authorizes assistance to privately owned community water systems, some states have laws or policies that preclude privately owned utilities from receiving DWSRF assistance.)

Appropriations for the program were authorized at $599 million for FY1994, and $1 billion annually for FY1995 through FY2003. Although the funding authority for the DWSRF program has expired, Congress continues to appropriate funds. Through FY2008, Congress has provided $10.3 billion for this program.

Congress added several new features to the DWSRF program to reflect experience gained under the Clean Water Act program and differences between the drinking water and wastewater industries. A key difference in the DWSRF is that privately owned as well as publicly owned systems are eligible for funding. Another distinction is that states may use up to 30% of their DWSRF grant to provide additional assistance, such as forgiveness of loan principal or negative interest rate loans, to help economically disadvantaged communities.[7]

Paralleling the Clean Water Act, the SDWA requires EPA to assess the capital improvement needs of eligible public water systems. Needs surveys must be prepared every four years. In contrast to the CWA, which includes a statutory allotment formula for SRF capitalization grants, EPA must distribute DWSRF funds among the states based on the results of the latest survey. Eligible systems include roughly 55,000 public and private community water systems and 21,400 not-for-profit noncommunity water systems. (See **Table 1** for a comparison of key features of the clean water and drinking water SRF programs.)

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[7] For more information, see CRS Report RS22037, *Drinking Water State Revolving Fund: Program Overview and Issues*, by Mary Tiemann.

EPA conducted its third survey of capital improvement needs for public water systems in 2003.[8] Based on this survey, EPA estimates that systems need to invest $276.8 billion in drinking water infrastructure improvements over 20 years to comply with drinking water regulations and to ensure the provision of safe water. This amount exceeds the 2001 needs survey estimate of $150.9 billion ($165.5 billion in 2003 dollars) by more than 60%. EPA attributed this increase to several factors, such as the inclusion in the latest survey of $1 billion in security-related needs, as well as funds needed for compliance with several new and pending regulations. Also, water systems improved their assessment of needs for infrastructure rehabilitation and replacement in 2003, which EPA determined had been under-reported in previous surveys. With the number of regulated drinking water contaminants now exceeding 90, and with more rules pending, these needs are expected to continue to grow. Consequently, stakeholders continue to press Congress to reauthorize and increase appropriations for this program.

[8] Environmental Protection Agency, *Drinking Water Infrastructure Needs Survey and Assessment: Third Report to Congress*, June 2005. EPA 816-R-05-001. Available online at [http://www.epa.gov/safewater/needs.html].

Table 1. Key Features of the Clean Water and Drinking Water State Revolving Fund Programs

	Clean Water SRF	Drinking Water SRF
Year authorized	1987	1996
Authorization	$8.4 billion (FY1989-1994)	$9.4 billion (FY1994-2003)
Appropriations through FY2008	$26.2 billion	$10.3 billion
Cumulative assistance (federal and state) through 2006	$55.0 billion	$13.9 billion
Eligible uses of fund (types of assistance)	Loans, refinance, insurance, guarantee, purchase debt, security for leveraging, 4% grant for administration	Loans, refinance, insurance, guarantee, purchase debt, security for leveraging
Loan terms	Interest between 0% and market rate; 20-year terms; longer terms allowed administratively in some states	Interest between 0% and market rate; 20-year terms; 30-year terms and subsidized loans (principal forgiveness) for economically disadvantaged systems
Eligible systems	Municipalities, intermunicipal, interstate, or state agency	Publicly and privately owned community and nonprofit, non-community drinking water systems
Eligible projects	Projects for wastewater treatment plants; qualified nonpoint source and estuary improvement projects	Projects to upgrade/replace drinking water source, treatment, storage, transmission and distribution
Ineligible projects	Operation and Maintenance (O&M)	Dams, reservoirs (unless for finished water), water rights (unless purchase through consolidation), O&M
Set-asides	No	Yes: up to 31% of grant (for administering DWSRF, public water system supervision, source water protection, capacity development, operator certification programs)
Disadvantaged assistance	No	Yes: up to 30% of grant (principal forgiveness), 30-year repayment
Transfers between SRFs[a]	Yes: up to 33% of clean water SRF capitalization grant amount	Yes: up to 33% of DWSRF capitalization grant amount

Source: CRS, adapted from EPA Drinking Water State Revolving Fund Program Report to Congress, Office of Water, EPA 918-R-03-009, May 2003.

a. Although SDWA statutory provision expired in FY2001, Congress has approved transfers in subsequent appropriations laws.

USDA Assistance Programs

While EPA administers the largest federal water infrastructure assistance programs, the U.S. Department of Agriculture (USDA) also provides funding. It administers grant and loan programs available to communities with populations of 10,000 or less, thus benefitting small communities, many of which have had problems obtaining assistance through the CWA and SDWA loan programs. Many small towns have limited financial, technical and legal resources, and have encountered difficulties in qualifying for and repaying loans. They often lack opportunities for economies of scale or an industrial tax base, and thus face the prospect of high per capita user fees to repay a loan for the full cost of a sewage treatment or drinking water project.

USDA's grant and loan programs are authorized by the Rural Development Act of 1972, as amended (7 U.S.C. § 1926). The purpose of these USDA programs is to provide basic amenities, alleviate health hazards, and promote the orderly growth of the nation's rural areas by meeting the need for new and improved rural water and waste disposal facilities. Loans and grants are made for projects needed to meet health or sanitary standards, including clean water standards and Safe Drinking Water Act requirements. In recent years, USDA officials have increased their coordination with state clean water and drinking water officials in administering their programs. They have done this both to better meet health and environmental goals and to minimize program redundancies and/or inconsistencies. For FY2008, Congress appropriated $535.4 million for USDA's water and waste disposal grant and loan programs, about $16 million less than in FY2007.[9]

Context for the Water Infrastructure Debate: Investment Needs

Some of the factors that have led to increased attention to water infrastructure reflect long-standing concerns (for example, how cities will meet regulatory requirements), while others are more recent (such as, new analyses of broader funding needs, including maintenance and repair of older systems). A number of interest groups — many with long-standing involvement, as well as new groups and coalitions — have assisted in bringing attention to these issues. Among them are the Water Infrastructure Network (WIN), a coalition of 29 state, municipal, environmental, professional, and labor groups organized in 1999, and the H_2O Coalition, organized in 2001, consisting of the National Association of Water Companies, the Water and Wastewater Equipment Manufacturers Association, and

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[9] In addition to providing support through these EPA and USDA programs, Congress is increasingly being asked to provide direct authorizations for individual projects developed by the Department of the Interior's Bureau of Reclamation and the U.S. Army Corps of Engineers. A key practical difference between these *projects* and EPA and USDA *programs* is that with individual project authorizations, there is no predictable assistance, or assurance of funding once a project is authorized. (For more discussion, see CRS Report RL30478, *Federally Supported Water Supply and Wastewater Treatment Programs*, by Betsy A. Cody, Claudia Copeland, Mary Tiemann, Nicole T. Carter, and Jeffrey A. Zinn.)

the National Council for Public-Private Partnerships. Two WIN reports on funding needs and policy have received considerable attention, and the H_2O Coalition has responded to some issues in the WIN reports. In April 2000, WIN issued a report estimating a $24.7 billion average annual investment gap for the next 20 years for municipal wastewater and drinking water systems to address new problems and system deterioration.[10] Over the 20-year period, according to WIN's analysis, $940 billion is required for wastewater and drinking water investments, and more than $1 trillion in O&M spending is required. A second WIN report, issued in 2001, recommended a multibillion dollar investment program in water infrastructure.[11]

EPA Needs Surveys

EPA's contribution to the debate over needs is primarily its wastewater and drinking water needs surveys. The Safe Drinking Water Act requires EPA to assess the capital improvement needs of eligible public water systems every four years thereafter. Concurrently, and in consultation with the Indian Health Service and Indian tribes, EPA must assess needs for drinking water treatment facilities to serve Indian tribes. Similarly, the Clean Water Act requires EPA, in cooperation with states, to report biennially to Congress on the cost of construction of all needed publicly owned wastewater treatment works in the United States (in reality, the clean water needs survey is done every four years).

Drinking Water Needs. The most recent drinking water needs survey, conducted in 2003 and issued in June 2005, covers the period from 2003 through 2023. As noted above, the survey indicates that systems need to invest $276.8 billion in drinking water infrastructure improvements over 20 years to comply with drinking water regulations and to ensure the provision of safe water. This amount exceeds the 2001 needs survey estimate of $165.5 billion (in 2003 dollars) by more than 60%. The 2003 survey includes funds needed for compliance with several recent regulations (including the revised arsenic and radium rules) and pending rules for radon and other contaminants. It also identified $1 billion in security-related needs. Also, water systems made efforts to improve reporting of needs for infrastructure rehabilitation and replacement, which EPA determined had been under-reported in the previous surveys.

Of the total national need of $276.8 billion, $160.5 billion (60%) is currently needed to ensure the provision of safe drinking water. EPA notes that a "current need" typically involves installing, upgrading, or replacing infrastructure to allow a system to continue to deliver safe drinking water and that systems with current needs are usually not in violation of a drinking water standard. EPA reports that, although all of the infrastructure projects in the needs assessment promote the health objectives of the act, $45.1 billion (16%) of the total is attributable to SDWA

[10] Water Infrastructure Network, *Clean & Safe Water for the 21st Century, A Renewed National Commitment to Water and Wastewater Infrastructure,* April 2000. (Published estimates used in this CRS report were adjusted by CRS to 2001 dollars.)

[11] Water Infrastructure Network, *Recommendations for Clean and Safe Water in the 21st Century,* February 2001. (Hereafter cited as WIN Recommendations.)

regulations, while $237 billion (84%) represents nonregulatory costs (e.g., routine replacement of basic infrastructure).[12]

Wastewater Needs. The most recent wastewater survey, conducted in 2004 and issued in 2008, estimates that $202.5 billion is needed for projects and activities eligible for Clean Water Act assistance.[13] This estimate includes $134.4 billion for wastewater treatment and collection systems ($10.5 billion more than the previous report), $54.8 billion for combined sewer overflow corrections ($1.5 billion less than the previous estimate), $9 billion for stormwater management ($2.8 billion more than the previous estimate), and $4.3 billion to build systems to distribute recycled water (a new category in this report). The total is 8.6% larger than needs reported in the previous survey, four years earlier. The increases are due to several factors, according to EPA: needs for rehabilitation of aging infrastructure, facility improvements to meet more protective water quality standards and, in some cases, providing additional treatment capacity for handling wet-weather flows. Needs for small communities (under 10,000 population) represented about 9% of the total.

The clean water needs survey does not separately identify needs for Alaskan Native villages, and only a few states report needs for Indian tribes. More comprehensive estimates are made by the Indian Health Service (IHS) of the U.S. Department of Health and Human Services, which operates a Sanitation Facilities Construction program pursuant to the Indian Sanitation Facilities Act (P.L. 86-121). IHS estimated that, as of the end of FY2005, more than140,000 American Indian and Alaska Native (AI/AN) homes needed sanitation facilities, including over 36,000 homes that needed potable water. The total needing safe water improvements is about 12% of all AI/AN homes, compared with about 1% of all U.S. homes, according to IHS. The backlog of documented Indian sanitation facility projects as of the end of FY2005 totaled more than $2 billion, with those projects considered by the IHS to be economically and managerially feasible totaling $990 million.[14]

Expressed as average annual costs, the EPA needs surveys estimate $13.8 billion for drinking water systems and $10.1 billion for wastewater systems. EPA acknowledges that needs estimates generally have been conservatively biased. First, all reported needs in both surveys must be documented with project-specific information. Second, needs that are ineligible for SRF funding are not reflected; thus, in the drinking water survey, needs for fire flow, dams, and untreated reservoirs are omitted. Neither EPA survey explicitly accounts for infrastructure needs due to population increases, since growth-related projects are not eligible for EPA funding. The wastewater needs survey does not include information about privately owned facilities or facilities that serve privately owned industrial facilities, military

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[12] U.S. Environmental Protection Agency, *Drinking Water Infrastructure Needs Survey and Assessment: Third Report to Congress*, June 2005.

[13] U.S. Environmental Protection Agency, *Clean Watersheds Needs Survey 2004, Report to Congress,* Washington, January 2008, 1 vol., available at [http://www.epa.gov/owm/mtb/cwns/2004rtc/toc.htm].

[14] U.S. Department of Health and Human Services, Indian Health Service, "FY2007 Budget Requests, Justification of Estimates for Appropriations Committees; Sanitation Facilities Construction," February 2006, p. IHF-11.

installations, national parks or other federal facilities, as they are not eligible for funding under the clean water SRF program. Finally, neither survey accounts for financing costs associated with utility borrowing to pay for capital investment. Despite various challenges and limitations, needs estimates have improved with experience. For the most recent drinking water needs survey, for example, EPA reported that state and water system efforts to correct past problems with significant under-reporting of needs appear to have been successful.[15]

CBO's Report on Future Investment

A 2002 report by the Congressional Budget Office (CBO) also contributes to the discussion about investment needs.[16] In that report, CBO presented two scenarios of future needs for capital investment and O&M costs, a low-cost case and a high-cost case. The two scenarios span the most likely possibilities that could occur, according to CBO, and present a range of estimates for each, reflecting the limited information available about existing water infrastructure. For example, CBO said, there is no accessible inventory of the age and condition of pipes (which account for the majority of both drinking water and wastewater systems' assets). As such, a shortage of data compounds the general analytic problem of making 20-year estimates of what would happen under current and currently anticipated trends.

CBO estimated that for the years 2000 to 2019, annual costs for investment will range between $11.6 billion and $20.1 billion for drinking water systems, and between $13.0 billion and $20.9 billion for wastewater systems, or between $24.6 billion and $41.0 billion for water and wastewater combined (in 2001 dollars). Additionally, CBO estimated that annual costs over the period for O&M, which are not eligible for federal aid, will range between $25.7 billion and $31.8 billion for drinking water and $20.3 billion to $25.2 billion for wastewater systems, or between $46.0 and $57.0 billion for water and wastewater combined.

The principal differences in costs under CBO's two scenarios reflect different assumptions about several factors: (1) the rate at which drinking water pipes will be replaced, (2) savings that may be associated with improved efficiency (e.g., demand management to reduce peak usage, consolidation of systems to achieve economies of scale, labor productivity), (3) the costs to wastewater utilities for controlling combined sewer overflows, and (4) the repayment period on borrowed funds.[17]

CBO estimated that, for both types of systems, the difference between current capital spending (approximately $22 billion by all levels of government in 1999) and future costs — what some call an investment funding gap — would be $3.0 billion annually in the low-cost scenario and $19.4 billion in the high-cost case. Together, the future costs under the low-cost scenario (which CBO believes is reasonable, given the uncertainty about the condition of existing infrastructure, prospects for

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[15] U.S. Environmental Protection Agency, *Drinking Water Infrastructure Needs Survey and Assessment: Third Report to Congress*, June 2005, p. 5.

[16] U.S. Congressional Budget Office, *Future Investment in Drinking Water and Wastewater Infrastructure,* November 2002, 58 p. (Hereafter cited as CBO 2002.)

[17] Ibid., pp. 18-22.

improved efficiency, and assumptions about borrowing) represent growth of 14% from 1999 levels, while under the high-cost case, the estimated increases represent growth of about 90%.

CBO also examined estimates in WIN's 2000 report, because of the public attention that it has received. CBO's analysis shows approximately an $18.6 billion difference between current spending and WIN's estimate of future annual costs, and is thus close to CBO's high-cost case. Investing at either the level in WIN's report or the CBO high-cost scenario would require nearly a doubling of current annual spending levels. WIN's single point estimate of annual investment needs for drinking water and wastewater ($40 billion) is similar to CBO's high-cost case estimate. In contrast, CBO's low-cost case estimate is $15.7 billion less than that in the WIN report (see **Table 2**), because of differences in assumptions concerning the timeline for replacing drinking water pipes, savings from efficiency, and borrowing terms.

Overall, in examining the 2000 WIN report, CBO was critical of a number of analytic aspects. In particular, while WIN includes financing costs in its analysis, WIN's estimates of total capital investment needs do not reflect "costs as financed." Costs as financed conveys the full costs of investments made out of funds on hand during the period analyzed and the debt service (principal and interest) paid in those years on new and prior investments that were financed through borrowing. Costs as financed are a kind of moving average that smooths out year-to-year changes in investment volume. In contrast, WIN's 2000 report includes total debt service on new investments from 2000 to 2019, regardless of when those payments occur, rather than the debt service actually paid during the period (on both pre-2000 and new investments). The difference is important, according to CBO, because utilities' past investments financed from 1980 to 1999 and still being paid off from 2000 to 2019 are smaller than the investments projected to be financed during the latter period. WIN's approach to estimating investment needs (capital plus financing) results in approximately a 20% over-estimate, according to CBO.[18]

EPA's Gap Analysis Report

In addition to the needs surveys, in 2002 EPA issued a study, called the Gap Analysis, assessing the difference between current spending and total funding needs for drinking water and wastewater infrastructure.[19] Using data from the needs surveys and updated information, the Gap Analysis estimated total needs for drinking water and clean water (capital investment plus financing costs, and operation and maintenance (O&M)) from 2000-2019, as well as the projected gap between current spending and needs. This report examined a range of estimates, based on two scenarios: a low-end estimate assuming a 3% annual real growth in revenues (an

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[18] Ibid., p. 19.

[19] U.S. Environmental Protection Agency, *The Clean Water and Drinking Water Infrastructure Gap Analysis,* September 2002, EPA 816-R-02-020, 50 p.

increase in user rates and equivalent increase in customer growth) and a high-end estimate assuming no growth in water utility systems' revenues.[20]

Using these two scenarios, the Gap Analysis estimates a 20-year investment gap between current spending levels and capital investment needs for wastewater and drinking water combined between $66 billion and $224 billion (in 2001 dollars). In addition, it estimates a 20-year gap in spending for O&M between $10 billion and $409 billion. Under EPA's analysis, the estimated average annual gap between current spending and investment needs is between $1.6 billion and $23.1 billion, and the average annual O&M gap is between $0.3 billion and $36.3 billion, depending on the scenario. Compared with estimates of baseline expenditures, EPA's projections imply an average annual increase in costs over the 20-year period that ranges from 2.8% to 85.8% for capital investment and O&M combined.

A January 2003 CBO report examined estimates in the 2002 CBO report and in EPA's Gap Analysis.[21] As shown in **Table 2**, the differences between EPA's and CBO's projections of total investment costs are not especially significant: both EPA's and CBO's high-end estimates ($46.5 billion and $41 billion, respectively) reflect a near doubling of baseline investment costs through 2019. WIN's 2000 estimate ($40 billion) has a similar implication. EPA's and CBO's low-end investment estimates ($25 and $24.6 billion, respectively) reflect less than a 15% increase in costs through 2019. Differences between EPA's and CBO's investment estimates are explained by differences in assumptions, such as the potential for efficiency savings and different time profiles for replacement of drinking water pipes. For most factors, CBO believes that a strong case cannot be made for the choice of one agency's estimates over the other, so long as the differences are recognized.

Greater differences are apparent between CBO's and EPA's high-end scenario estimates for O&M ($57 billion and $82 billion, respectively). According to CBO, that difference stems from EPA's adopting the unrealistic assumption that drinking water infrastructure is replaced in large quantities early in the 20-year period, rather than being replaced more evenly throughout the span, with high O&M costs throughout the period as a by-product of the early increase in capital stock. In WIN's report, O&M annual cost estimates are closer to CBO's high-end scenario than to EPA's.

Table 2 summarizes estimates from the 2000 WIN report, the 2002 CBO report, and EPA's Gap Analysis on average annual costs for water infrastructure (wastewater and drinking water combined) and the potential average annual increase above current spending levels that would be required to achieve such expenditures.

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[20] For each scenario in the Gap Analysis, EPA presents a range of estimates and a point estimate within each range. For simplification, CRS refers to these point estimates, but readers should consult the EPA report for full discussion.

[21] U.S. Congressional Budget Agency, *Future Spending on Water Infrastructure: A Comparison of Estimates from the Congressional Budget Office and the Environmental Protection Agency,* letter report, January 2003, 14 p.

Table 2. Estimated Costs for Water Infrastructure

(billions of dollars)

	WIN	CBO 2002		EPA gap analysis	
		Low-end	High-end	Low-end	High-end
Average annual cost 2000-2019					
— Investment	40.3[a]	24.6	41.0	25.0	46.5
— O&M	52.6	46.1	57.0	46.1	82.0
Average annual cost above baseline spending (gap) 2000-2019					
— Investment	18.6[a]	3.0	19.4	1.6	23.1
— O&M	11.8	7.1	18.1	0.3	36.3

Source: CRS.

a. The $40.3 billion and $18.3 billion in this table reflect CBO's re-estimate of investment needs in the WIN 2000 report. CBO re-estimated the WIN information to reflect investment costs as financed, in order to give comparability with CBO's and EPA's analyses.

Issues

While estimates of funding needs have become one focal point for discussion, some argue that trying to focus on precise needs estimates is not as important as recognizing the general need. For example, CBO's reports and EPA's Gap Analysis caution that projections of future costs associated with water infrastructure are highly uncertain and could lie outside of the ranges that they present. Different assumptions could increase or decrease the results. CBO explained this point in its 2003 report.[22]

> Because available data are limited, the agencies must use many assumptions to develop their projections, and the 20-year projection window provides ample opportunity for unforeseen developments to influence costs. Data limitations make it impossible for the agencies to know even baseline investment costs with certainty.

As is evident from their analyses of various investment scenarios, CBO and EPA believe that funding gaps are not inevitable, if other steps are taken. Both emphasize that funding gaps occur only if capital and O&M spending remains unchanged from present levels. Future spending and other measures that systems could adopt to reduce both types of costs, such as asset management processes,[23] could significantly alter estimates of future needs. How a gap would be filled raises a number of other issues. Whether water infrastructure needs over the next 20 years are $200 billion or $1 trillion, they are potentially very large, and the federal government is unlikely to provide 100% of the amount. Questions at issue include

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[22] Ibid., p. 1.

[23] Asset management is a planning approach for conducting integrated assessments of future capital and operating needs to ensure that investments are made efficiently.

what is the precise problem to be solved; who will pay, and what is the federal role in that process; and how to deliver federal support.

Priorities: What Are the Problems to Be Solved?

Defining the scope of the water infrastructure problem is a key issue. As described previously, traditionally the CWA and SDWA have assisted projects needed to upgrade and improve wastewater and drinking water systems for compliance with federal standards. There still are significant needs for those core projects: for example, the 2003 clean water needs survey reports that more than one-half of the $171 billion in total treatment needs are for projects to correct overflows from existing municipal sewers, particularly sanitary sewer overflows (SSOs).[24] The EPA estimates that, of the $276.8 billion in drinking water needs, $45 billion (16%) is required for water systems to comply with regulations. However, these needs are expected to increase as the number of SDWA standards grows. Relatedly, $165 billion (60%) of total needs is for projects that water utilities consider a high priority for ensuring the continued delivery of safe drinking water.

Infrastructure Replacement. While not disregarding needs for compliance-related projects, stakeholders also are focusing on the problem of projects that have not traditionally been eligible under federal aid programs — major repair and replacement of existing systems. Currently, federal funds may be used for projects that involve minor system repairs (such as correcting leaky pipes that allow infiltration or inflow of groundwater into sewer lines) but may not be used for major rehabilitation, or extensive repair of existing sewers that are collapsing or are structurally unsound. In many cities, systems that currently meet standards and provide adequate service are, according to advocacy groups, reaching the end of their service-life and will require substantial investment in the near future. The American Water Works Association's 2001 report focused solely on the need to reinvest in aging drinking water infrastructure. It estimates that nationally over the next 30 years, $250 billion may be required to replace worn out facilities and systems.

The replacement problem is occurring not because of neglect or failure to do routine maintenance, AWWA and others say, but because water infrastructure facilities and pipes installed decades ago are now wearing out. Most pipes were installed and paid for by past generations in response to population growth and economic development booms of the 1890s, World War I, 1920s, and post-World War II. The oldest cast iron pipes, dating from the late 1800s, have an average useful life of about 120 years, while pipes installed after World War II have an average life of 75 years. The useful life of pipe varies considerably, based on such factors as soil conditions, materials used, and character of the water flowing through it. Also, pipe deteriorates more rapidly later in the life cycle than initially. AWWA says, "Replacement of pipes installed from the late 1800s to the 1950s is now hard upon us, and replacement of pipes installed in the latter half of the 20th Century will

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[24] SSOs are releases of raw sewage from sanitary sewer collections systems before the wastewater reaches the treatment plant. These discharges are a major type of wet weather pollution.

dominate the remainder of the 21st century."[25] Treatment plant assets are more short-lived than pipes, with typical service lives of 15 to 50 years. Thus, many that were built in response to environmental standards in the 1970s and 1980s also will begin to be due for replacement in a few years.

This concern over infrastructure deterioration recalls an earlier period when infrastructure was a hotly debated topic. In the 1980s, there was much debate among policymakers about an infrastructure funding gap and the need for federal solutions to the perceived problem that America's public facilities were wearing out faster than they were being replaced. Some said that, because of declining public investment, America's infrastructure was in ruins. Analysts proposed strategies for planning, financing, and managing investments to address decay of the nation's public works infrastructure.[26] After a period of publicity and attention, debate about an "infrastructure crisis" waned. Congress did not enact legislation creating substantially new federal approaches to infrastructure but did reauthorize funding for several existing programs, including wastewater.

Today, analysts may differ over whether an infrastructure crisis did, in fact, exist then and whether local officials made choices sufficient to defer the issue for a later day. In the end, this earlier infrastructure debate resulted in little obvious action and without the breakdowns some had warned of. However, the current concerns may reflect a new situation: AWWA says that the replacement problem being debated today is not that utilities are faced with making up for a historical gap in the level of replacement funding. Rather, it is that utilities must ramp up budgets to prevent a replacement gap from developing in the near future; that is, to avoid getting behind.

Security. With the exception of the latest EPA drinking water needs survey, none of the investment needs reports discussed previously (WIN report, or those by CBO and EPA) accounts for increased security-related needs that utilities have begun to identify. In its 2002 report, CBO said:

> Because water systems are still developing estimates of the costs for increasing security in the wake of the September 11 attacks, the estimates do not include those expenses — but preliminary reports suggest that security costs will be relatively small compared with the other costs for investment in infrastructure.[27]

One partial estimate for wastewater systems reported that, among large wastewater utilities, operators identified $135 million in security-related needs for the period 2002-2006, with approximately one-quarter of those reporting saying that their needs exceed $1 million.[28]

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[25] AWWA Report, p. 11.

[26] See, for example, Pat Choate and Susan Walter, *America in Ruins*. Council of State Planning Agencies, 1981, 97 p.; and Roger J. Vaughan and Robert Pollard, *Rebuilding America, Planning and Managing Public Works in the 1980s,*Council of State Planning Agencies,1984, Vol. 1, 182 p.

[27] CBO 2002, p. x.

[28] Association of Metropolitan Sewerage Agencies, *The AMSA 2002 Financial Survey*, 2003, (continued...)

Although poorly quantified and potentially small relative to overall infrastructure needs, the costs of addressing security concerns for drinking water systems are expected to be significant. The Bioterrorism Preparedness Act of 2002 (P.L. 107-188) required all community water systems serving more than 3,300 persons to assess their vulnerabilities to terrorist attack or other intentional acts to disrupt the provision of safe and reliable drinking water supplies. Having done so, many of these systems now are taking, or planning to take, steps to improve the security of their facilities and to protect sources of drinking water. The AWWA has estimated that the roughly 8,400 community water systems covered by the Bioterrorism Act would have to spend more than $1.6 billion just to implement the most basic steps needed to improve security (such as better controlling access to facilities with fences, locks, perimeter lights, and alarms at critical locations). This estimate does not include the capital costs of upgrades to address vulnerabilities identified in vulnerability assessments, such as hardening pumping stations, chemical storage buildings, transmission mains, adding redundant infrastructure, or relocating pipelines of facilities. Efforts to estimate costs have been hampered by the fact that the security measures needed for utilities are very site-specific. However, the AWWA estimates that, nationwide, community water systems will need to invest billions of dollars to address identified vulnerabilities.[29]

The total security need estimated from the 2003 drinking water needs survey is $1 billion. According to EPA, the survey provides only a partial estimate of security needs, as it was done while water systems were expanding their security evaluation and planning efforts. Many water systems had completed vulnerability assessments and corrective action plans, but they frequently lacked cost estimates for making security improvements. EPA expects that such needs will be reported more thoroughly in future assessments.[30]

To cover the costs of making security improvements, some water utilities have imposed rate increases or reallocated existing resources. However, many others have been increasing rates to pay for projects needed to comply with new regulations, but had not contemplated the need for additional resources to address security concerns. Asserting that homeland security is primarily a federal responsibility, and that the needs are large, some individual communities and water associations have approached Congress in search of assistance.[31] In the Bioterrorism Preparedness Act, Congress authorized funding for FY2002 through FY2005 for EPA to provide financial assistance to drinking water systems for several purposes, including making basic security enhancements, but no funding was provided. EPA has identified numerous security improvements that are eligible for funding through the drinking

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[28] (...continued)
p. 79.

[29] Statement of Howard Neukrug on behalf of the American Water Works Association, in: U.S. House, Committee on Transportation and Infrastructure, Subcommittee on Water Resources and the Environment, *Aging Water Supply Infrastructure*, Hearing, 108th Congress, 2nd session, April 28, 2004 (108-63), p. 61.

[30] U.S. Environmental Protection Agency, *Drinking Water Infrastructure Needs Survey and Assessment: Third Report to Congress*, June 2005, pp. 10-11.

[31] Ibid.

water and clean water state revolving fund programs,[32] and infrastructure bills in the 108th, 109th, and 110th Congresses specified that projects to improve security were eligible for assistance under the clean water and drinking water state revolving funds. However, these funds are used primarily to comply with Safe Drinking Water Act and Clean Water Act requirements, and it is uncertain how readily these funds might become available for security measures.[33]

Funding Other Priorities. Wastewater SRF funding is used for construction of publicly owned municipal wastewater treatment plants, implementing state nonpoint pollution management programs, and developing and implementing management plans under the National Estuary Program (CWA, Section 320).[34] Drinking water SRFs may provide assistance for expenditures that will facilitate compliance with national drinking water regulations or that will "significantly further the health protection objectives" of the Safe Drinking Water Act. There are many proposals for expanding the scope of activities eligible for SRF funding, in addition to meeting major replacement and security-related needs, raising numerous tradeoff questions for policymakers.

Past legislative proposals (such as H.R. 720 and S. 3500 in the 110th Congress and S. 1400 in the 109th Congress) would have added a number of new types of projects to those already eligible for SRF assistance: water conservation; water reuse, reclamation, or recycling; measures to increase facility security; and implementation of source water protection plans, for example. The rationale for using federal assistance is that investments in some of these approaches could reduce overall needs for capital investment. All, arguably, could benefit water quality protection and improvement, as do traditional infrastructure investments, and supporting them through the popular mechanism of SRFs would help ensure comparatively secure funding. But expanding the scope of eligibility also arguably dilutes the current focus of these programs, at a time when traditional needs remain high. This tension already exists with the wide range of set-asides authorized under the drinking water SRF, where, in addition to funding infrastructure projects, states may reserve up to 31% of their federal capitalization grant for a range of other purposes. For example, states may use up to 10% of their grant to implement wellhead protection programs and another 10% to fund local source water protection initiatives. (See discussion below of set-asides, under "Delivering Federal Support.")

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[32] See U.S. Environmental Protection Agency, "Use of the Clean Water State Revolving Fund to Implement Security Measures at Publicly Owned Treatment Works," at [http://www.epa.gov/owm/cwfinance/cwsrf/security.pdf]; and "Use of the Drinking Water State Revolving Fund (DWSRF) to Implement Security Measures at Public Water Systems," EPA-816-F-02-040, at [http://www.epa.gov/safewater/dwsrf/pdfs/security-fs.pdf].

[33] For more information on drinking water security issues and funding, see CRS Report RL31294, *Safeguarding the Nation's Drinking Water: EPA and Congressional Actions*, by Mary Tiemann. Also see CRS Report RL32189, *Terrorism and Security Issues Facing the Water Infrastructure Sector*, by Claudia Copeland.

[34] According to EPA, 37 clean water SRF programs have funded more than 6,100 nonpoint source pollution control projects, providing $2.1 billion in SRF funding since 1990. No estuary projects have been funded through the SRF.

Many argue that greater investment in managing nonpoint sources of water pollution would especially benefit public health and water quality. According to state data compiled by EPA, polluted runoff is the major source of water quality problems in the United States. Water quality survey data indicate that 40% of surveyed U.S. waterbodies are impaired by pollution (meaning that waters fail to meet applicable standards) and that surface runoff from diffuse areas such as farm and ranch land, construction sites, and mining and timber operations is the chief cause of impairments, while municipal point sources contribute a much smaller percentage of water quality impairments to most waters.[35] The possible cost of practices and measures to address the nonpoint pollution problems has not been comprehensively documented. Nevertheless, it is conceivable that investments in nonpoint pollution abatement (e.g., grants for nonpoint pollution management projects under the Clean Water Act, technical and financial assistance to farmers through USDA, Safe Drinking Water Act grants to protect sources of drinking water) could have equal or greater environmental benefit than investments in water infrastructure. For example, New York City is funding an extensive watershed protection program, including areas far from the metropolitan area, in an effort to avoid the need to build a filtration plant that would cost the city several billion dollars.

Growing populations in many areas of the country are placing increasing demands on water supplies and wastewater treatment facilities. Yet, even without new growth, many people in existing small and rural communities do not have access to public sewers or water supply and, thus, are using alternative systems to help them comply with environmental laws and to solve public health problems. Local officials face a challenge of striking a balance between ensuring that water and wastewater services are affordable, but also providing sufficient revenue for system needs. To deliver these services, they often face challenges arising from economic, geographic, and technological impediments. Outside of EPA's and USDA's traditional programs, it appears that Congress is increasingly being asked to authorize direct financial and technical assistance for developing or treating water, including rural water supply projects to be built and largely funded by the Bureau of Reclamation of the Department of the Interior, water recycling projects built and partially funded by the Bureau, and pilot programs for water supply and wastewater treatment projects funded by the U.S. Army Corps of Engineers. To yet another group of stakeholders, these, too, reflect priority problems in need of legislative attention and federal solutions. Indeed, the 109th Congress passed legislation (P.L. 109-451) authorizing the Bureau of Reclamation to establish a program for design and construction of rural water supply projects in 13 Reclamation states in the West.

Policymakers face decisions about priorities and tradeoffs, since spending decisions often are essentially a zero-sum game: that is, what priority should be given to traditional infrastructure projects needed to comply with standards, versus the emerging problem of infrastructure replacement, versus nonpoint pollution management or other competing activities also having environmental benefits? Since not all can be supported, do some have greater priority than others? What should the federal government support? Should eligibility for SRF funding be expanded to

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[35] U.S. Environmental Protection Agency, Office of Water, *National Water Quality Inventory, 2000 Report*, August 2002, EPA 841-R-02-001, 207 p.

include less traditional activities? Is there clearly a federal role for some or all activities, or is a larger federal role justified for some than for others?

The Federal Role

Many stakeholders are seeking substantially increased federal spending on water infrastructure for reasons described in this report. Among groups involved in water infrastructure (states, cities, equipment manufacturers, the construction industry), a long-standing issue is the gap between funding needs and available resources from federal, state, and local sources.

Data compiled by EPA demonstrate that federal capitalization grants are the largest, but not the only, source of monies in the SRFs. For example, cumulatively from 1996 through 2005, drinking water SRFs have had $11.3 billion in funds available for projects. Of the total, $6.6 billion was provided by capitalization grants, while the remainder — more than $5 billion — came from state match contributions, leveraged bonds, principal repayments, and interest earnings. Likewise, cumulatively from 1988 through 2006, clean water SRFs have had $53 billion in funds available. Slightly less than half ($24 billion) has come from federal capitalization grants, while the remainder similarly derived from state matching funds, leveraged bonds, principal repayments, and interest earnings. In addition, state assistance outside of the SRF programs is an important source of total funds available for water infrastructure. For example, from FY1991 through FY2000, states made about $13.5 billion available for drinking water and wastewater projects under state-sponsored grant and loan programs and by selling general obligation and revenue bonds.[36]

Local government officials estimate that, on average, ratepayers currently pay about 90% of the total cost to build their drinking water and wastewater systems (through direct local financing or loan repayments to SRFs); federal funds provide the remainder.[37] (Small rural systems depend more on government aid than do large systems.) According to the National League of Cities, these capital costs, plus operations and maintenance for which localities also are responsible, total about $60 billion annually for drinking water and wastewater systems.[38] Cities also say that they have been raising water and sewer rates to accommodate increases in operating and maintenance costs, which have risen 6% above inflation annually.[39] Municipal officials contend that increased local fees and taxes alone cannot solve all funding problems. This is true, they say, both with respect to costs of meeting future needs

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[36] U.S. Government Accountability Office, *Water Infrastructure: Information on Federal and State Financial Assistance,* November 2001, GAO-02-134, p. 18 (formerly the General Accounting Office).

[37] U.S. House, Committee on Transportation and Infrastructure, Subcommittee on Water Resources and the Environment, *Meeting Clean Water and Drinking Water Infrastructure Needs,* Hearing, 105th Congress, 1st session, April 23, 1997 (105-18). p. 307.

[38] Statement of Bruce Tobey on behalf of the National League of Cities on Water and Wastewater Infrastructure Needs in: U.S. House, Committee on Transportation and Infrastructure, Subcommittee on Water Resources and the Environment, *Water Infrastructure Needs,* Hearing, 107th Congress, 1st session, March 28, 2001 (107-8), p. 131.

[39] Ibid., p. 132.

(e.g., new treatment requirements) and costs of reinvesting in aging infrastructure. Water and wastewater officials acknowledge that they will continue to cover the majority of water infrastructure needs, but believe that doing so presents a significant challenge in keeping water affordable. This is especially true in small cities, rural areas, and cities with shrinking populations and/or local economies where a possible doubling or tripling of water and sewer rates to meet all needs could be required. If some such cities are unable to finance replacement or improvement of their water infrastructure, declining service levels, violations of water quality requirements, and threats to public health and the environment could occur, officials say.[40]

Assertions about financial impacts and affordability are at the heart of many stakeholders' efforts seeking greater federal support. The Water Infrastructure Network, for example, says that local sources alone cannot be expected to meet the challenge of large water and sewer needs, and that the benefits of federal help accrue to the nation as a whole, since water moves across political boundaries. Moreover, WIN argues that clean and safe water is no less a national priority than are national defense, an adequate system of interstate highways, or a safe and efficient aviation system. Highways and aviation currently "enjoy sustainable, long-term federal grant programs," supported by trust fund revenues, while water infrastructure does not.[41] In its 2001 report, WIN recommended a five-year, $57 billion authorization above current funding for loans, grants, loan subsidies and credit assistance to capitalize state-administered grant and loan programs which it believes would cover about one-half of the estimated five-year capital funding shortfall. WIN estimated that, even with that additional investment, average household water and sewer rates would increase over the next 20 years, but in WIN's projections, average rate increases would be 100%, compared with 123% without such a boost in federal support.[42]

Some analysts dispute the view that federal funding solutions are essential to meeting future investment needs. According to this view, funding problems are in many cases due to the failure of local communities to assign a high priority to water and wastewater services and result in failure to set local water rates and other user charges at levels that cover capital and operating expenditures. This is especially true in the case of municipally or publicly owned utility systems which, unlike investor-owned systems, often do not support the full cost of service through rates. Publicly owned systems predominate in the wastewater industry (constituting more than 95%). In the drinking water industry, approximately 33% of public water systems are privately owned; however, most of these systems are small, serving roughly 15% of the U.S. population. The H_2O Coalition, another group in the water infrastructure debate, believes that it is not possible to state with any confidence what is unaffordable to customers and therefore what the magnitude of government support should be, because few utilities have done detailed long-term needs projections and

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[40] Water Infrastructure Network, "Commonly Asked Questions and Answers about the WIN Report," *Water Infrastructure Now*, May 5, 2001, p. 5. (Hereafter cited as WIN Questions and Answers.)

[41] WIN Recommendations, p. 3.

[42] WIN Questions and Answers, p. 3.

analyzed ways of addressing these needs through rates.[43] "Rate shocks" which result from large rate increases can be managed to a degree, analysts say, by financing, ratemaking, and conservation strategies. They argue that if water services continue to be subsidized by federal funds, subsidies should not reward utilities' inefficiency, but should be used strategically and equitably.[44] Some advocate using needs-based subsidies to help low-income households by providing direct payment assistance or funding a lifeline rate.

CBO has repeatedly argued that federal spending programs to support water infrastructure (direct project grants and SRF capitalization grants, as well as credit subsidies in the form of loans, loan guarantees, and tax preferences) can have a number of unintended consequences. In a February 2005 report (one of a regular biennial series) on the budgetary implications of policy choices, one of the policy options that CBO presents is a phaseout of federal capitalization grants for SRFs over a three-year transition period. CBO cites several economic rationales for doing so. For example, grants may encourage inefficient decisions about water infrastructure by allowing states to lend money at below-market interest rates, in turn reducing incentives for local governments to find less costly ways to control water pollution and provide safe drinking water. Also, federal contributions may not result in increased total investment if they are merely replacing funding that state and local sources would otherwise have provided.[45]

In its 2001 report, WIN recommended initially doubling federal support for water infrastructure, and increasing it by 500% after five years. Others, including the H_2O Coalition, doubt that increased federal support of that magnitude is necessary or appropriate. Even if policymakers agree that there is a federal role, significant questions remain about defining that role and agreeing on priorities.

Delivering Federal Support

The question of how federal financial support is delivered to water infrastructure projects involves several issues, including the state-level mechanism for administering funding, composition of aid (loans and grants), and assistance for private as well as public entities. Related issues are impacts of other federal requirements, use of set-asides, and how funds are allotted to states.

Administrative Entity. Financial aid provided through the clean water and drinking water SRFs is administered by state-level agencies designated in agreements signed by EPA and individual states. Many evolved from the agencies that previously administered the Clean Water Act construction grant program that preceded the SRF program. In many states, SRFs are managed by the state

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[43] "Comparison of Recommendations of the WIN and the H_2O Coalition," February 16, 2001, see [http://www.nawc.org/issues/issues-h.html].

[44] Statement of Janice Beecher on behalf of the National Association of Water Companies, in: U.S. House, Committee on Transportation and Infrastructure, Subcommittee on Water Resources and the Environment, *Water Infrastructure Needs,* Hearing, 107th Congress, 1st session, March 28, 2001 (107-8), p. 55.

[45] U.S. Congressional Budget Office, *Budget Options,* February 2005, p. 104.

environmental agency or branches of that agency responsible for implementing the CWA and the SDWA. In other states, they are managed by separate financing authorities or offices. About 30 states currently administer the two SRF programs jointly; the remainder administer parallel SRF programs. State officials say that, where administration of the two is not joined, there are good reasons for maintaining the separation. Section 302 of the 1996 SDWA amendments included a provision allowing states to transfer a portion (up to 33%) of a capitalization grant between the two programs to give states funding flexibility. That original authority expired in FY2001, but Congress has continued to extend it through annual appropriations acts since FY2002. Since 1999, 13 states and Puerto Rico have used this provision to transfer funds between their clean water and drinking water SRF programs.

In its 2001 report, WIN recommended that the SRF concept be replaced with an alternative mechanism called State Water and Wastewater Infrastructure Financing Authorities which would work with state clean water and drinking water programs but would handle the infrastructure banking aspects for both. WIN says that this would be highly efficient, enabling a single state agency to determine priorities and appropriate financial assistance instruments. Most state officials now involved with the two SRF programs object to this proposal, believing that it would de-construct what exists and is working well now. It would also substitute a new organizational entity for that which individual states have determined works best for them, including the 20 states that prefer separate SRF programs. Also, by giving decisionmaking authority to a new entity, the WIN concept would shift authority from existing state agencies. WIN supporters believe that differences between their proposal and the views of state program officials are not vast, but many state officials disagree.

The Type of Assistance Provided: Grants and Loans. One issue that divides the stakeholder groups is whether to provide assistance through grants, as well as loans, with cities and the WIN group favoring a significant place for grants, and most states and the H_2O Coalition favoring loans in preference to grants.

Both SRF programs authorize states to make loans at or below market interest rates, including zero interest loans. However, for several years, both small and large cities have urged Congress to explicitly authorize water infrastructure grants, in addition to loans, to provide flexible assistance best suited for particular community and state needs. Thus, the drinking water SRF, enacted nine years after the clean water SRF program, allows up to 30% of capitalization grants to be used to provide loan subsidies to disadvantaged communities. Grants that do not require repayment obviously are preferred by communities. For example, some small communities that lack an industrial tax base or means to benefit from economies of scale find it difficult to repay a loan for 100% of the cost of water infrastructure projects. Some larger cities also seek grants, on the basis that water infrastructure is just one of numerous costly capital needs that they must meet, and a partial subsidy in the form of a grant would help make those costs more affordable for ratepayers.

Small and disadvantaged communities' financing problems also have been addressed by permitting a longer loan repayment period. By spreading out repayment, communities can reduce the amounts due on an annual basis, thus lessening the amount of rate increases needed to finance the repayment (although total financing costs over the life of the loan may be higher). Under both SRF programs, annual principal and interest repayments begin one year after project completion and are to be fully amortized 20 years after project completion. Under the drinking water SRF, however, states may allow economically disadvantaged communities up to 30 years to repay loans. The Clean Water Act does not currently permit 30-year repayments, but House Appropriations Committee report language accompanying EPA's FY1998 appropriations bill (P.L. 105-175) encouraged EPA to allow states to issue bonds allowing for clean water SRFs with repayment terms of greater than 20 years. Consequently, EPA has allowed a few states (e.g., Massachusetts, West Virginia, Maryland) to issue 30-year clean water SRF loans.

Many state officials are reluctant to use a portion of the SRF to award grants, principally because, to the extent that part of the SRF is used for making grants, the corpus of the loan fund and its ability to be a self-sustained long-term source of funding are diminished. States acknowledge that a loan "buy down," in the form of granting forgiveness of a portion of the SRF loan principal, can be a useful option for dealing with disadvantaged communities. However, many states prefer to limit the use of grants as much as possible and would oppose being obliged to make grants. State water quality officials who previously administered the Clean Water Act's construction grant program and others (including CBO) believe that grants can undermine efficient investments by leading to substitution of federal funds for state and local funds, rather than augmenting state and local investment, and distort decisions about preventive maintenance, treatment technology, and excess capacity. According to EPA, states are being conservative in using the principal forgiveness authority under the drinking water SRF: since 1996, only 16 states have done so, and assistance provided with principal forgiveness has totaled less than 3% of all drinking water SRF assistance since that time.

Members of the H_2O Coalition favor limited and targeted federal assistance, so that utilities are encouraged to attain and maintain business-like operations. If federal assistance is provided, the Coalition, like many state officials, advocates that it should be primarily in the form of low-interest or zero-interest loans. The Coalition supports assistance for low-income families to supplement their water and sewer bills, where necessary, either paid to the low-income families or directly to the utility. Some loan forgiveness (as under the drinking water SRF) or grants (with at least 50% local cost share) are options that the Coalition supports in rare cases, and only so long as assistance produces long-term solutions and ensures that federal monies are used cost-effectively. Except in cases where virtually all of a utility's customers are impoverished, assistance for low-income households should be favored over grants, this group says. According to the Coalition, grants or loans with substantial forgiveness subsidize all customers' rates, even those that are able to afford the full cost of service, and therefore are not an efficient use of scarce federal assistance.[46]

Federal Funds for Private Infrastructure Systems. Currently under the drinking water SRF program, eligible loan recipients include community water systems, both publicly and privately owned, and not-for-profit noncommunity water systems (e.g., schools with their own water supply). Eligible loan recipients for

[46] H_2O Coalition, "What is the Water Infrastructure Problem and What are the Solutions?" Issue Paper, February 26, 2001, pp. 7-11.

wastewater SRFs are any municipality, intermunicipal, interstate or state agency, but not privately owned utilities. A number of stakeholders advocate that SRF funds be made available to privately owned wastewater systems, as well. This would "level the playing field" between the two programs, it is argued, and also would encourage public-private partnerships and privatization.

Another issue involving the private sector arises from the Internal Revenue Code. Under federal tax law, certain activities financed by the issuance of state and local bonds have a special status because the interest earned is exempt from federal income taxation. Tax-exempt financing enables state and local governments to borrow at a lower interest rate than either private business or the federal government must pay on taxable debt. In general, tax-exempt status applies to activities broadly defined as having public purpose. Some specific activities considered to have both public and private purposes are eligible for tax-exempt financing. However, these public/private activities are subject to a cap that limits the volume of private activity bonds (PABs) state and local governments may issue annually. PABs for water infrastructure are subject to the volume cap, and tax-exempt financing can be done if the project is able to secure an allocation from the volume cap.

Because private water bonds compete under this cap with other private bond uses such as housing, industrial development, and student loans, some groups favor legislation that would exempt all PABs for water and sewage facilities from the volume cap. The President's FY2009 budget request included a proposal to exempt PABs used to finance drinking water and wastewater infrastructure from the PAB unified state volume cap, in order to provide states and communities greater access to PABs to help finance water infrastructure needs. A bill to authorize such a change (H.R. 6194) was introduced in the 110th Congress. Similar legislation has been introduced in the past (e.g., H.R. 1708 in the 109th Congress). Current law provides such an exemption for government-owned and operated solid waste disposal facilities. Opponents argue that restrictions on tax-exempt financing should be maintained, because of the costs to the federal government, in terms of income tax revenues foregone. Similarly, some opponents say that the bonds represent an inefficient allocation of capital, favoring some projects over others, and increase the cost of financing traditional governmental activities. Also in the 110th Congress, H.R. 1959 was introduced to permit interest on federally guaranteed USDA water, wastewater, and essential community facilities loans to be tax exempt. (For more information, see CRS Report RL31457, *Private Activity Bonds: An Introduction*, by Steven Maguire.)

Other Federal Tax Issues. A second federal tax issue related to the Internal Revenue Code concerns arbitrage. If proceeds of tax-exempt bonds issued by state and local governments in connection with SRF programs are invested in securities that pay a higher yield than the yield on the bonds, the earnings are termed arbitrage profits. Unchecked, state and local governments could substitute arbitrage earnings for a substantial portion of their own citizens' tax effort. Thus, Congress has decided that such arbitrage should be limited, and that tax-exempt bond proceeds must be used quickly to pay contractors for the construction of the capital facilities for which the bonds were issued. Federal tax law requires that bond proceeds be spent out during a specified period; if not, the arbitrage earnings must be rebated to the U.S.

Treasury. (For information, see CRS Report RL30638, *Tax-Exempt Bonds: A Description of State and Local Government Debt*, by Steven Maguire.)

The Internal Revenue Service (IRS) places arbitrage restrictions on SRF reserves. In the case of the SRFs, this issue can arise when governments use SRF monies to borrow funds at tax-exempt rates in order to issue municipal bonds and then invest the funds received from the issues in higher earning taxable securities. The process of using federal capitalization grants and state matching funds as collateral to borrow in the public bond market so as to increase the pool of available funds for project lending is termed *leveraging*. It is used by more than one-half of states, according to EPA. EPA's Environmental Finance Advisory Board has expressed concern that the interpretation of the IRS arbitrage limitations reduces the amount of funds potentially available for infrastructure projects because it requires the yield on invested reserves to be no greater than the bond maturity rate, and it has urged EPA to support amending the Internal Revenue Code to provide that monies contributed to SRFs be freed from arbitrage earnings restrictions.[47]

Many states urge that amounts used as reserves to secure bonds for SRF projects be exempted from the arbitrage rebate rules so that any interest earnings could be used for additional investment in water infrastructure projects. The Council of Infrastructure Financing Authorities, which represents most of the SRF organizations, has estimated that if arbitrage restrictions were lifted, SRFs could earn an additional $100 to $200 million annually on their funds. If these earnings were used as reserves to secure additional bonds, they could provide an additional $200 to $400 million annual investment in infrastructure projects. However, others respond that without the existing arbitrage rule, state and local governments could issue tax-exempt bonds solely for the purpose of gaining arbitrage profits, at the expense of greater revenue losses to the federal government and ultimately higher interest rates on bonds whose proceeds actually are used for the acquisition or construction of capital facilities.[48]

The 109th Congress considered this issue. In P.L. 109-115 (providing FY2006 appropriations for the Treasury Department), Congress directed the Secretary of the Treasury to submit a report to the House and Senate Committees on Appropriations providing a legal basis for applying arbitrage bond regulations to the reserve funds held by the clean water and drinking water SRFs, which generally contain replacement proceeds (from loan repayments) but not bond proceeds.[49]

Federal Cross-Cutting Requirements. Under both SRF programs, a number of federal authorities, executive orders, and government-wide policies apply

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[47] U.S. Environmental Protection Agency, Environmental Finance Advisory Board, "Arbitrage Relief Would Increase Funds Available to Meet Critical Water and Sewer Funding Needs," May 7, 2006, 3 p.

[48] U.S. Environmental Protection Agency, *The Drinking Water State Revolving Fund Program, Report to Congress*, EPA 918-R-03-009, May 2003, p. 95.

[49] Conference Report to accompany H.R. 3058, Making Appropriations for the Departments of Transportation, Treasury, and Housing and Urban Development, the Judiciary, District of Columbia, and Independent Agencies for the Fiscal Year Ending September 30, 2006, H.Rept. 109-307, November 18, 2005, p. 207.

to projects and activities receiving federal financial assistance, independent of program-specific statutory requirements, and many stakeholders favor repealing their applicability to water infrastructure projects. These include environmental laws (e.g., Clean Air Act, Endangered Species Act), social legislation (e.g., Age Discrimination Act, Civil Rights Act), and economic and miscellaneous laws (Davis-Bacon Act, Uniform Relocation and Real Property Acquisition Policy Act of 1970, and procurement prohibitions under environmental laws and Executive Order 11738). These federal cross-cutting requirements apply only to projects funded directly by the federal capitalization grants, but not to SRF activity made from loan repayments, interest earned, or other state monies contained in the SRF.

In addition, the clean water SRF attaches 16 specific statutory requirements to activities funded directly by federal capitalization grants that are carryover ("equivalency") requirements from the prior construction grant program (e.g., specific project evaluation requirements).

Under both SRF programs, projects financed with funds directly made available by federal capitalization grants are subject to Environmental Impact Statement requirements of the National Environmental Policy Act. Projects funded by other monies in the SRF also must undergo an environmental review; however, a state may select its own method for conducting environmental reviews, if approved by EPA.

Many stakeholders believe that these other federal cross-cutting requirements are burdensome and costly and, in many cases, only ancillary to benefits of water infrastructure projects. One particularly contentious issue is compliance with the Davis-Bacon Act which requires, among other things, that not less than the locally prevailing wage be paid to workers employed, under contract, on federal construction work "to which the United States or the District of Columbia is a party." Critics of Davis-Bacon say that it unnecessarily increases public construction costs and hampers competition (with respect to small and minority-owned businesses). Supporters say that the law helps stabilize the local construction industry by preventing competition from firms that could undercut local wages, and perhaps working conditions, and thus compete unfairly with local contractors.

Congress has added Davis-Bacon prevailing wage provisions to more than 50 separate program statutes, including the Clean Water Act and generally to the Safe Drinking Water Act. However, the applicability of Davis-Bacon to the clean water SRF expired in FY1994, when the authorizations in P.L. 100-4 expired. Further, since the drinking water SRF program was established in 1996, EPA has interpreted the SDWA to not require applicability of the Davis-Bacon Act to all construction projects supported by SRFs. (For information, see CRS Report RL31491, *Davis-Bacon Act Coverage and the State Revolving Fund Program Under the Clean Water Act*, by William G. Whittaker.) Inclusion of its requirements in the CWA and SDWA SRF programs has been controversial, and that controversy was a prominent reason that no water infrastructure financing legislation has been enacted recently.

Set-Asides. The utility of set-asides that allow for using a portion of SRF capitalization grants for program purposes other than directly constructing infrastructure is likely to be debated. Under the clean water SRF, a state must reserve the greater of 1% of its capitalization grant or $100,000 each year to carry out specified planning requirements under the CWA. Under the drinking water SRF, a state may use up to 31% of its capitalization grant for specified SDWA programs including supervision of public water systems, operator certification, compliance capacity development, and state and local source water protection initiatives (some uses require a 50% state match).

Reserving a large amount of funds, even for related implementation activities, necessarily limits the funds available to the state for assisting infrastructure projects. Also, several of the set-aside activities have their own funding authority; thus, a concern for states is that Congress may rely on the SRF to fund other SDWA requirements instead of providing the authorized appropriations, and the overall funding for drinking water activities may be diminished. Drinking water program officials acknowledge this problem, but many believe that set-asides are a useful means of ensuring that monies will be available for activities that might otherwise not have a secure source of funds. Because states have some flexibility, in fact, few are using the full amount that could be reserved under the set-asides. According to EPA, only a few states have used the full 31% that the law allows, and the average amount reserved by all states since 1996 is 16%.

Many state clean water program officials have a different view of mandatory set-asides, based on experience administering the previous construction grant program which for a time required states to reserve a portion of federal funds for specified types of projects. Because of problems in spending those set-aside funds (e.g., finding beneficial projects on which to spend all the required reserved funds) and extensive oversight by EPA, many of them now oppose the reservation of core funds (especially mandatory set-asides), except for covering SRF administrative costs.

A separate issue relates to set-asides for administration. Under both the CWA and SDWA programs, states may reserve up to 4% of their federal capitalization grants annually for the reasonable costs of administering the SRF. As the SRFs have developed and loan portfolios have grown, many states argue that an amount equal to 4% of the allotment is insufficient for administering the program. This problem is exacerbated by the fact that congressional appropriations of capitalization grants generally have remained steady (and for the clean water SRF, actually have been reduced nearly 50% since FY2004). Many states impose fees on borrowers, which has the effect of increasing costs for the borrower. Thus, an issue of concern to many is increasing the amount that states are allowed to reserve for administrative purposes.

Allotment of Funds and Congressionally Directed Project Grants. Another issue of interest is how federal funds are allocated among the states. Capitalization grants for clean water SRFs are allotted according to a state-by-state formula in the Clean Water Act. It is a complex formulation consisting basically of two elements, state population and capital needs for wastewater projects. Because the allocation formula has not been revised since 1987, yet needs and population have changed, the issue of state-by-state distribution of federal funds is likely to be an important topic when legislation is considered. In contrast, capitalization grants for drinking water SRFs are allotted by EPA based on the proportional share of each state's needs identified in the most recent national drinking water needs survey, not according to a statutory allotment formula. (For information, see CRS Report

RL31073, *Allocation of Wastewater Treatment Assistance: Formula and Other Changes*, by Claudia Copeland.) Among the questions likely to be discussed are, should a single formula apply to both programs? Should allocation follow from a statutory or administrative formula? Do EPA's needs surveys provide an accurate basis for state-by-state distribution? If programs are expanded to include eligibility for new activities, such as pollution prevention and watershed protection, how should they be reflected in state-by-state allocations? Crafting an allotment formula has been one of the most controversial issues debated during past reauthorizations of the Clean Water Act. The dollars involved are significant, and considerations of "winner" and "loser" states bear heavily on discussions of alternative formulations.

A related issue is whether a portion of federal water infrastructure funds will continue to be allocated in the form of congressionally directed appropriations for specified communities' projects, which have become increasingly prominent and are often referred to as earmarks. In recent years, congressional appropriators have dedicated a significant portion of annual water infrastructure assistance as grants for specific communities, both small and large. The federal share of costs under these grants is 55%. For example, for FY2008 (P.L. 110-161), Congress appropriated $689 million for clean water SRF capitalization grants, $829 million for drinking water SRF grants, and $177 million in earmarked grants for 282 listed projects. Appropriations directed by Congress for identified projects enable legislators to assist communities otherwise unable to fully qualify for state-administered programs, or those seeking a grant rather than a loan that must be repaid. State officials that administer the SRF programs oppose these types of grants because such congressional actions deny states the ability to determine priority for project funding. (For information, see CRS Report RL32201, *Water Infrastructure Projects Designated in EPA Appropriations: Trends and Policy Implications*, by Claudia Copeland.)

Research on New Technologies

The basic technologies used by communities to meet wastewater and drinking water needs have changed little for several decades, in part because utility officials often favor using conventional, familiar systems and technologies. This is particularly the case in the wastewater sector where regulatory requirements have been relatively static for years. Although this has long been true in the drinking water sector as well, the situation is changing as new regulations are requiring many public water systems to apply new technologies.

EPA's revised drinking water standard for arsenic has drawn particular attention to the need for research on treatment technologies that are affordable and suitable for small water systems. In the conference report for the Consolidated Appropriations Act for FY2005 (P.L. 108-447), Congress expressed concern that many small communities, especially rural communities in the West, will not be able to afford to comply with the arsenic rule and that it could pose a large financial hardship on these communities.[50] Congress has provided funding specifically for research on cost-effective arsenic removal technologies for small systems.

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[50] H.Rept. 108-792, to accompany H.R. 4818, p. 1567.

However, overall federal support for research and development (R&D) of new drinking water and wastewater technologies is limited. While much of EPA's drinking water research is focused on health effects studies, the identification of feasible treatment technologies is a central component of EPA's drinking water standard setting process, and technology research has received support. However, EPA's water research budget often has fallen short of its regulatory needs, and consequently, competition for available funding has been considerable.[51]

According to the Water Infrastructure Network, technology R&D is supported at the federal level mainly by programs of EPA's Office of Research and Development and EPA's Environmental Technology Verification (ETV) Program. Also, Congress has directed that EPA provide appropriated funds to nonprofit research foundations including the Water Environment Research Foundation ($3 million in FY2006 and $3.9 million in FY2005) and the American Water Works Association Research Foundation ($1 million in FY2006 and $4.9 million in FY2005). The ETV Program began in 1995 to verify the performance of innovative technology developed by the private sector and to accelerate the entrance of new technologies in all media. In the water and drinking water areas, technologies have been verified for a number of packaged drinking water systems especially needed for small community water supplies. Pilots also are underway to evaluate source water protection technologies and urban wet weather flow control technologies. In its 2001 report, WIN recommended that Congress authorize $250 million annually for a new Institute of Technology and Management Excellence to support the development and use of innovative technologies that would reduce the cost of meeting drinking water and clean water requirements and replacing water infrastructure.[52]

The CBO also has noted that one option to increase federal support for water infrastructure would be increased federal spending on R&D that could reduce water systems' costs and improve efficiency, such as technical R&D into new pipe materials, construction and maintenance methods, and treatment technologies. Economic principles suggest that federal involvement may be appropriate to increase cost-effectiveness when other entities, such as private firms and state governments that may fund R&D for water systems, do not have adequate incentive to consider the spillover benefits that would accrue from a national perspective as a result of research investments. Increased federal support of technical R&D could take the form of additional research projects managed by EPA, larger federal grants to private organizations, or both.[53]

In the past, Congress has attempted to advance new and innovative technologies in other ways, in addition to R&D activities. Beginning with the 1977 amendments to the Clean Water Act, Congress authorized specific incentives for such technologies, in particular by increasing the federal share under the construction grant program for innovative and alternative technology projects that reuse or recycle

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[51] See, for example, the GAO report, *Drinking Water Research: Better Planning Needed to Link Needs and Resources,* GAO/RCED-99-273, September 1999, 30 p.

[52] Water Infrastructure Network, *Recommendations for Clean and Safe Water in the 21st Century*, pp. 11-12.

[53] CBO 2002, pp. 33-34.

wastewater and sludge, reduce costs, or save energy consumption. The act also provided for 100% modification or replacement of innovative or alternative systems in the event of technological failure or significantly increased operating costs, as a safety measure to reduce the potential uncertainty of using risky or unproven wastewater treatment technologies.

The federal funding bonus and the potential for full replacement if a wastewater system failed were seen by states and cities as significant incentives for using technologies other than conventional treatment systems. However, these incentives were funded as set-asides from construction grants. These set-asides were not universally popular among state officials at the time, and they were not extended when the clean water SRF program was created. In 1989, EPA estimated that, compared with conventional treatment processes, for every dollar invested in designing and constructing an innovative project, 40 cents was saved over the life of the facility. Many now believe, however, that under the clean water SRF program, without the incentive of bonus funds or 100% replacement grants, few communities are constructing projects that utilize unproven or unfamiliar technology.

The Safe Drinking Water Act has no such incentives, but regulatory pressures and population growth are forcing both water and wastewater utilities to assess the potential of alternative treatment technologies. In this regard, issues for congressional consideration could include possible financial incentives or regulatory incentives (such as allowing some additional compliance flexibility) for use of innovative technology, as well as increased federal support for technology R&D.

Congressional and Administration Activity, 107th to 110th Congresses

Momentum in Congress to consider the issues discussed in this report has grown since the 107th Congress, partly in response to urgings of stakeholder groups. During this period, the Administration has promoted a number of steps to ensure that investment needs are met in an efficient, timely, and equitable manner.

Congressional Activities. House and Senate committees held oversight hearings on water infrastructure financing issues during the first session of the 107th Congress, and in the second session, the House Transportation and Infrastructure Committee approved H.R. 3930, a bill authorizing $20 billion in clean water SRF assistance for five years. No committee report was filed. The Senate Environment and Public Works Committee reported legislation authorizing $35 billion in total funding over five years for the clean water and drinking water SRF programs (S. 1961, S.Rept. 107-228). No further action occurred on either bill, in large part due to controversies over provisions in both bills to apply requirements of the Davis-Bacon Act to SRF-funded water infrastructure projects (discussed above) and also over CWA grant allocation formulas in the two measures.

Attention to these issues resumed in the 108th Congress. First, in July 2003, the House Transportation and Infrastructure Subcommittee on Water Resources and Environment approved H.R. 1560, legislation similar to H.R. 3930, the bill approved by that committee in 2002. H.R. 1560 would have authorized $20 billion for the clean water SRF program for FY2004-FY2008. It included several provisions intended to benefit economically disadvantaged and small communities, such as allowing extended loan repayments (30 years, rather than 20) and additional subsidies, including principal forgiveness and negative interest loans, for communities that meet a state's affordability criteria. It also included provisions to require communities to plan for capital replacement needs and to develop and implement an asset management plan for the repair and maintenance of infrastructure that is being financed. The Water Resources and Environment Subcommittee continued to examine infrastructure issues and, in April 2004, held a hearing on aging water supply infrastructure.[54]

In October 2004, the Senate Environment and Public Works Committee reported S. 2550 (S.Rept. 108-386), authorizing $41.25 billion over five years, including $20 billion for the clean water SRF program and $15 billion for the drinking water SRF program. The bill included a new formula for state-by-state allocation of clean water SRF grants, and expansion of the types of projects and activities eligible for clean water SRF grants. It would have directed states to reserve a portion of their annual clean water and drinking water SRF capitalization grants for making grants to eligible communities, and further would have required EPA to establish a grant program to help small water systems comply with drinking water regulations. (For discussion, see CRS Report RL32503, *Water Infrastructure Financing Legislation: Comparison of S. 2550 and H.R. 1560*, by Claudia Copeland and Mary Tiemann.) No further action occurred on either bill. Once again, the issue of the applicability of the prevailing wage requirements of the Davis-Bacon Act to SRF-funded projects affected consideration of the legislation, but criticism also included objection by some states to funding allocation formulas in the bills and opposition by the Administration to funding levels.

During the 109th Congress, the Senate Environment and Public Works Committee reported a water infrastructure financing bill, S. 1400 (S. Rept 109-186). Similar to S. 2550 in the 108th Congress, this bill would have extended both SRF programs (authorizing $20 billion over five years for the clean water SRF program and $15 billion drinking water SRF). It would have revised and updated the CWA formula for state-by-state allocation of SRF monies and would have specified that the prevailing wage requirements of the Davis-Bacon Act would apply to all projects financed from an SRF. It also would have directed the EPA to establish grant programs for small or economically disadvantaged communities for critical drinking water and water quality projects; authorized loans to small systems for preconstruction, short-term, and small-project costs; and directed the EPA to establish a demonstration program to promote new technologies and approaches to water quality and water supply management. No further action occurred on this bill.

Water infrastructure financing also received consideration in the 110th Congress, but, again, no legislation was enacted.[55] In March 2007, the House passed H.R. 720,

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[54] U.S. House, Committee on Transportation and Infrastructure, Subcommittee on Water Resources and the Environment, *Aging Water Supply Infrastructure*, Hearing, 108th Congress, 2nd session, April 28, 2004 (108-63), p. 78.

[55] For additional information, see CRS Report RL33800, *Water Quality Issues in the 110th*
(continued...)

the Water Quality Financing Act of 2007. It was substantially similar to legislation that the House Transportation and Infrastructure Committee's Water Resources and Environment Subcommittee approved in the 108th Congress (H.R. 1560, described above). It would have authorized $14 billion for the clean water SRF program for FY2008-FY2011. It included several provisions intended to benefit economically disadvantaged and small communities, such as allowing extended loan repayments (30 years, rather than 20) and additional subsidies (e.g., principal forgiveness and negative interest loans) for communities that meet a state's affordability criteria. H.R. 720 included provisions to require communities to plan for capital replacement needs and to develop and implement an asset management plan for the repair and maintenance of infrastructure that is being financed.

In September 2008, the Senate Environment and Public Works Committee approved S. 3617 (S.Rept. 110-509), the Water Infrastructure Financing Act, similar to the measure that the committee approved in the 109th Congress (S. 1400). S. 3500 would have authorized $20 billion for grants to capitalize the Clean Water Act SRF program and $15 billion for Safe Drinking Water Act SRF capitalization grants through FY2012. The bill would have expanded eligibility for clean water SRF assistance, including, for example, projects that implement stormwater management, water conservation or efficiency projects, and water and wastewater reuse and recycling projects. S. 3500 included a number of provisions to make the clean water and drinking water SRF programs more parallel, such as allowing SRF assistance to be used by private as well as public wastewater treatment systems. It also included several provisions to benefit small or economically disadvantaged communities, such as through new technical assistance and more generous loan terms.

Administration Activities. Throughout this period, the Bush Administration has addressed water infrastructure in a number of general ways, but has not offered legislative proposals of its own. The Administration opposed the SRF authorization levels proposed in bills in recent Congresses, saying that those levels exceed the Administration's targets for federal investment in water infrastructure and do not support the President's priorities of defense and homeland security. The debate was joined in the presentation of the President's annual budget request, where the Administration identified a federal capitalization target of $6.8 billion for the clean water SRF program for 2004 through 2011, supported by annual appropriations of $730 million. The Administration also said that it supports annual appropriations of $850 million for the drinking water SRF program through FY2018.[56] That amount of total funding, EPA officials said, combined with state matching, loan repayments, and other resources, would enable the clean water SRF to eventually revolve at $3.4

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[55] (...continued)
Congress: Oversight and Implementation, by Claudia Copeland, and CRS Report RL34201, *Safe Drinking Water Act: Selected Regulatory and Legislative Issues*, by Mary Tiemann.

[56] In FY2007, the President requested $688 million for clean water SRF capitalization grants and $842 million for drinking water SRF grants; Congress appropriated $1.1 billion and $838 million, respectively. In FY2008, the President's budget requested $688 million for clean water SRF grants and $843 million for drinking water SRF grants; Congress appropriated $689 million and $829 million for the two programs, respectively. For additional information, see CRS Report 96-647, *Water Infrastructure Financing: History of EPA Appropriations*, by Claudia Copeland.

billion annually and the drinking water SRF to revolve at $1.2 billion annually and be self-sustaining in the long run.[57]

The Bush Administration argued that funding needs are not solely the responsibility of the federal government, and that actions on the part of local governments are also required to help close the gap. Stakeholder groups concur, at least to the extent of agreeing that the problem is not solely the responsibility of any single level of government or entity, and that all must act to find solutions. But many stakeholders have argued that the level of federal investment endorsed by the Administration is insufficient to maintain investment levels in water infrastructure that are needed to achieve the nation's goals for safe and healthy water.

While saying that federal and state funding can help water utilities meet future needs, EPA's principal water infrastructure initiative has been to support other types of responses to these issues. In particular, since 2003 EPA has promoted strategies that it terms the Four Pillars of Sustainable Infrastructure.[58] The Four Pillars are:

- *Better Management.* EPA believes that better management practices like asset management, environmental management systems, consolidation, and public-private partnerships can offer significant savings for water utilities. Asset management is an inventory-based approach to planning, based on condition and risk, to assess future capital and operating needs. Regionalization or consolidation can in some cases enable utilities to achieve savings (and compliance) by combining physical and institutional assets and/or managerial and technical support.

- *Full-Cost Pricing.* Ensuring that sufficient revenues are in place to support the costs of doing business is key to constructing, operating, and maintaining infrastructure and can encourage efficient water use.

- *Efficient Water Use.* The need for costly infrastructure can be reduced by better management of water use. Options include metering, water reuse, water-saving appliances, water-saving landscaping techniques, and public education.

- *Watershed Approaches to Protection.* This pillar centers on the concept that, in addressing infrastructure needs for water supply and water quality, it is important to look more broadly at water resources in a coordinated way, to ensure that actions achieve the greatest benefit on a watershed-wide basis.

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[57] U.S. Environmental Protection Agency, *FY2006 Justification of Appropriations, Estimates for the Committee on Appropriations,* February 2005, p. STAG-68; *FY2004 Justification of Appropriations,* February 2003, p. SA-37.

[58] U.S. Environmental Protection Agency, *Sustainable Water Infrastructure for the 21st Century.* See [http://www.epa.gov/waterinfrastructure/].

EPA has pursued a Sustainable Infrastructure Leadership Initiative in partnership with water utilities to promote the Four Pillars. The purpose of the initiative is to identify new and better ways of doing business in the water and wastewater industries and promote them widely, and thus ensure sustainability of water systems. For example, EPA has worked to encourage utility rate structures that lead to full cost pricing and will support water metering and other conservation measures. EPA also encourages consumers to use water-efficient products (e.g., residential bathroom products), with the intent of reducing national water and wastewater infrastructure needs by reducing projected water demand and wastewater flow, thus allowing deferral or downsizing of capital projects.

Conclusions

The preceding discussion identifies a number of issues that Congress, the Administration, and stakeholders continue to debate regarding water infrastructure needs and concerns. Many of the issues already are the subject of advocates' recommendations and policy positions. Only recently, however, have some begun to address the long term challenge of actually paying for the larger financial commitment that many of them seek and, in particular, of identifying alternatives to finance a larger, sustained federal role. Some may wish to fund a larger amount of federal spending for water infrastructure entirely out of general revenues in the U.S. Treasury, but that faces substantial hurdles and competition with many other government priorities. Thus, several questions arise: if a substantial financing gap exists that cannot be met by improved efficiencies or local revenue enhancement, and if a larger federal financial role is determined to be appropriate, where would that money come from? Are there alternative revenue sources that could be identified to support increased federal involvement?

Some analytic work has already been done on these questions, including research by academics and interest groups.[59] EPA has contributed analysis in various ways, including a study requested by Congress in the mid-1990s that examined financial mechanisms to enhance the capability of governments to fund mandated environmental goals.[60] In addition, the EPA's Environmental Finance Advisory Board has developed various publications, including *A Guidebook of Financial Tools*, which provides a comprehensive review of financing mechanisms, and related tools that may help communities pay for environmental projects and lower compliance costs.[61]

Environmental advocates generally are less engaged in debates about water infrastructure than groups representing states, cities, and those involved in

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[59] For example, see Clean Water Council, *America's Environmental Infrastructure: A Water and Wastewater Investment Study,* 1990, 46 p.

[60] U.S. Environmental Protection Agency, *Alternative Funding Study: Water Quality Fees and Debt Financing Issues, Final Report to Congress*, June 1996, 99 p.

[61] Environmental Financial Advisory Board and Environmental Finance Center Network, *A Guidebook of Financial Tools: Paying for Sustainable Environmental Systems,* April 1999 revision. This and other publications by the Environmental Finance Advisory Board are available online at [http://www.epa.gov/efinpage/].

constructing facilities. However, some now argue that increased federal investment is needed to fix water quality problems caused by discharges of untreated and inadequately treated sewage and that "the federal government should greatly increase its contribution to water infrastructure needs through a clean water trust fund," which they call the best long-term source of sewage treatment funding.[62]

Among the options under discussion are various types of water-related fees that could be dedicated to water infrastructure and other water quality projects, including one based on water withdrawals or use, permit fees, effluent fees, chemical feedstock fees, and environmentally "green" product fees. Each such option has economic and equity impacts, spillover effects, and questions about administration that need thorough assessment. In June 2005, a House Transportation and Infrastructure subcommittee held hearings on alternative means to fund water infrastructure projects in the future. At one hearing, witnesses discussed creating a national clean water trust fund that would conceptually be similar to trust funds that exist for highway and aviation projects. Witnesses and subcommittee members discussed difficulties in identifying potential revenue sources for such a trust fund that would be deemed fair and equitable. A second hearing addressed other financing options, such as expanded use of tax-exempt private activity bonds, and more efficient management techniques, such as asset management programs and sustainable infrastructure initiatives. In the 109th Congress, legislation was introduced to establish a $7.5 billion federal trust fund for wastewater infrastructure improvements. This bill, H.R. 4560, contemplated a system of user fees to create the fund, but the source of revenue was not specified. No further action occurred on this bill, and finding consensus on the revenues to support such a large spending increase is a challenge that has eluded proponents so far.

Beyond discussion of trust funds or similar mechanisms, increased public/private partnerships are advocated by some, and other options also may merit exploration. As difficult as it may be for policymakers to resolve the many infrastructure financing issues, such as those discussed in this report, resolving how to pay for water infrastructure is no less a challenge.

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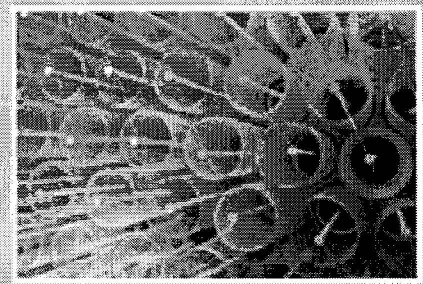
[62] Natural Resources Defense Council and Environmental Integrity Project, *Swimming in Sewage*, February 2004, pp. 57-58.

AMERICAN WATER

The Benefits of Infrastructure Replacement Surcharges



Walter Lynch
President of Regulated Operations
American Water

NARUC 120th Annual Convention
November 17, 2008

Purpose of Today's Discussion

- American Water overview
- What are infrastructure surcharges?
- What is the need?
- The Pennsylvania example
- Other AW Utility Programs
- Rate impacts
- Benefits

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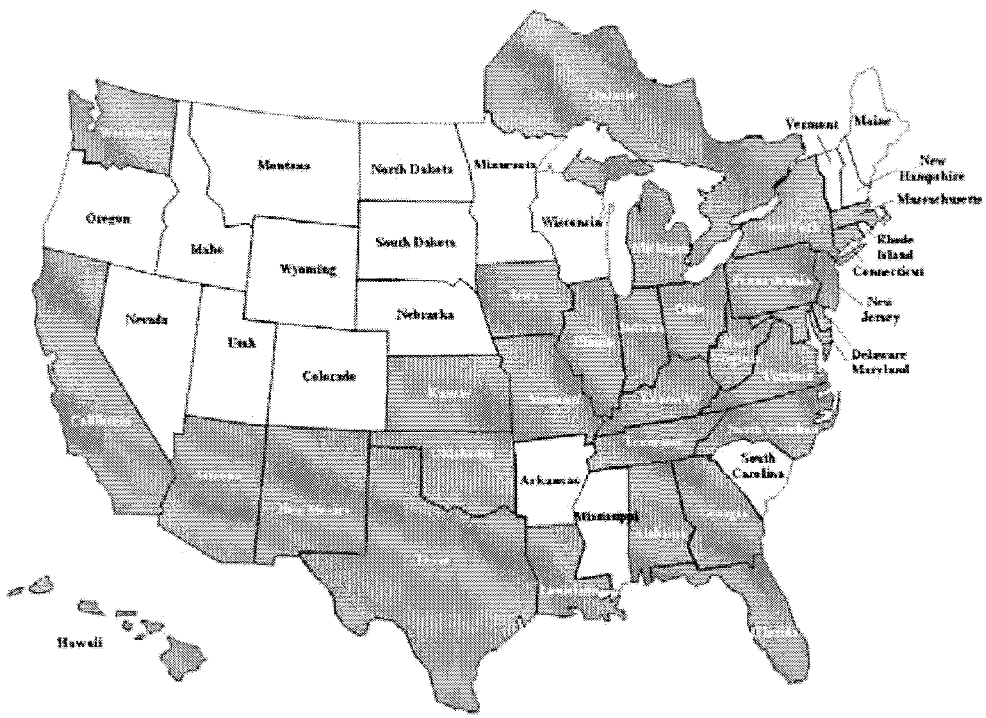
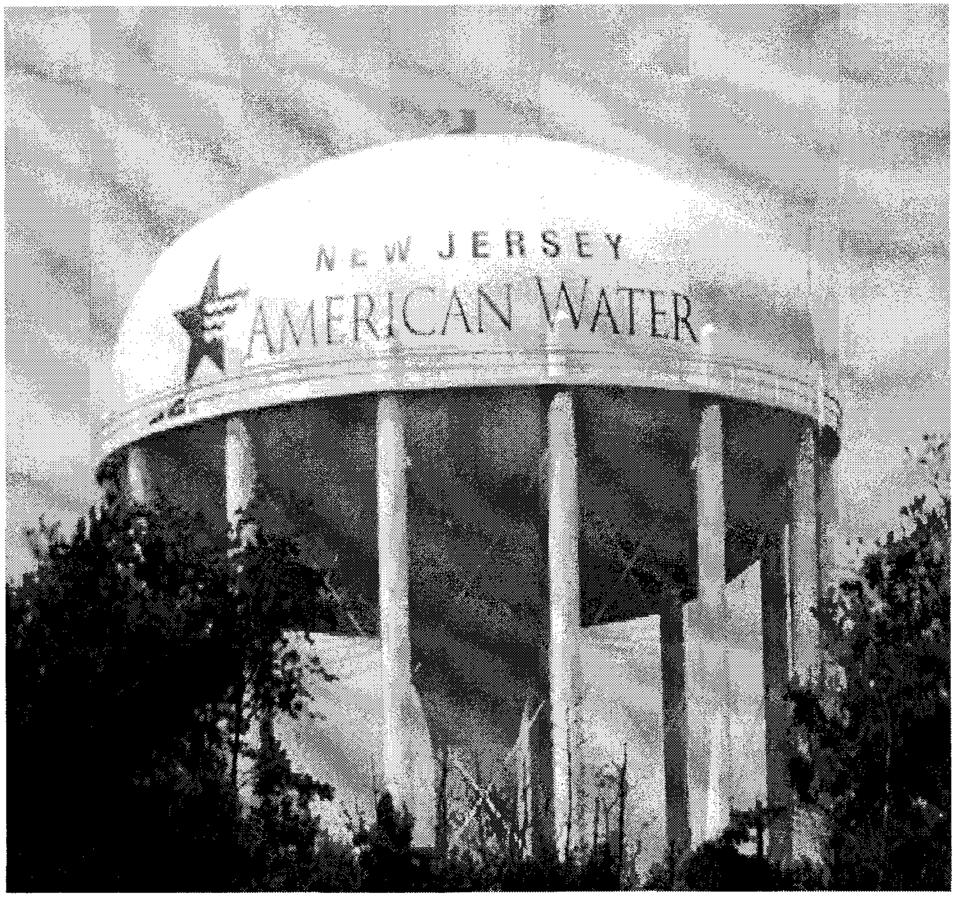
American Water



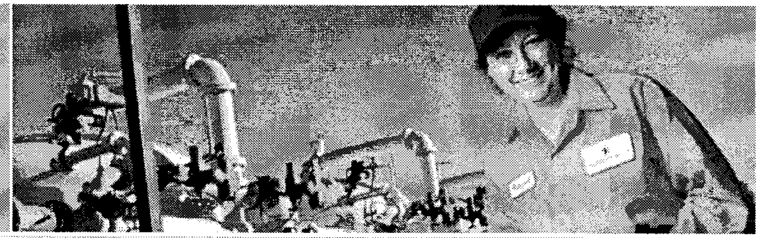
- Heritage dates back to 1886
- Largest water services provider in U.S.
- Serves approximately 15 million people in more than 1,600 communities
- Operations in 32 states and Ontario, Canada
- More than 7,000 employees



Facts & Figures

(owned Assets)

- 372 individual service areas
- 46,000 miles of distribution mains
- 80 surface water treatment plants
- 600 groundwater treatment plants
- 1,000 groundwater wells
- 45 wastewater treatment plants



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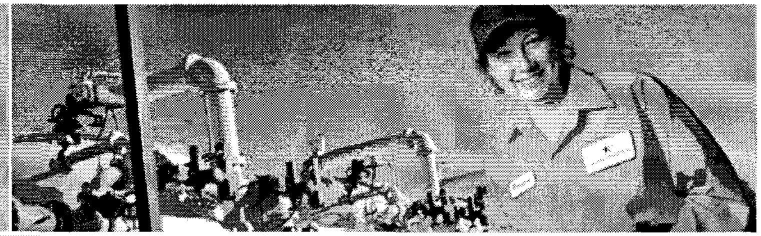
What Are Infrastructure Surcharges?

- Mechanisms to pass through to customers the **return on** (rate of return) and **return of** (depreciation expense) the capital needed to **replace** water or wastewater company infrastructure on a periodic basis <u>without filing a full rate case</u>



The Need for Infrastructure Replacement Programs

Infrastructure Replacement and Compliance with increasing SDWA & CWA Quality Requirements.

- 2002 USEPA Clean Water and Drinking Water GAP analysis
  - **Drinking Water: $154 billion - $446 billion through 2019 (pt.est. = $274 billion.**
  - **Clean Water: $331 Billion - $450 billion through 2019 (pt.est. $662 billion.**
  - **Total: $485 billion – $896 billion through 2019 (pt. est = $662 billion)**
- June 2005 USEPA Drinking Water Infrastructure Needs Survey and Assessment
  - $276 billion over 20 years* (former estimate: $154 Billion)
  - $263.7 billion (50 states)
- 20 year water/wastewater infrastructure costs could exceed $1 trillion

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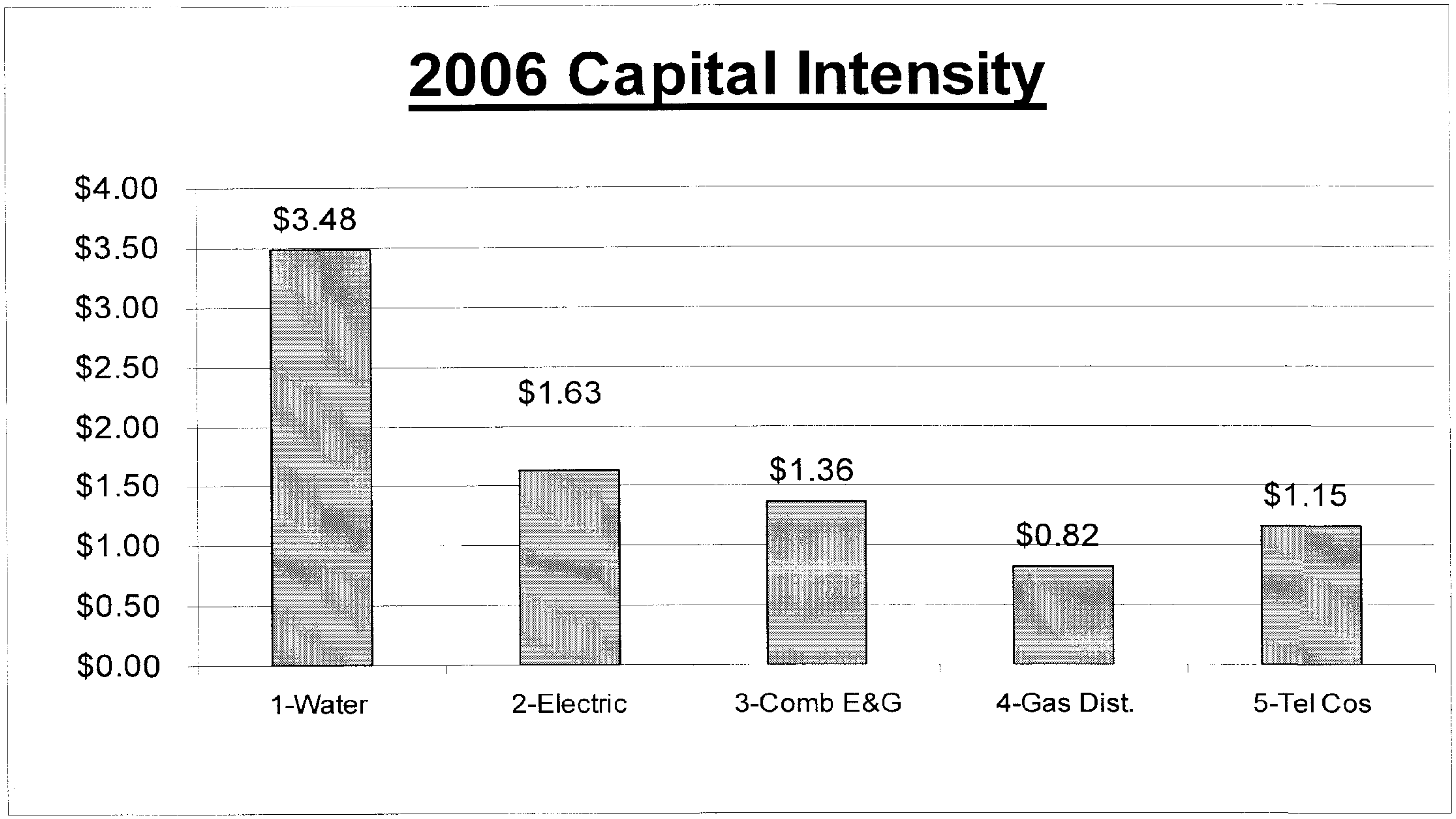
The Need for Infrastructure Replacement Programs (cont'd)

- **Cost of $1 to install 1 foot of main in 1900 can exceed $100 / foot today**

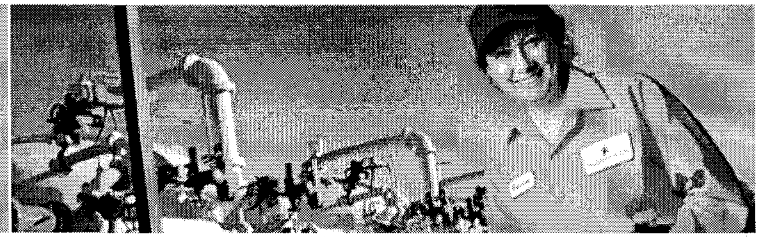
- **Regulatory Lag acts as a disincentive to necessary infrastructure replacement investment**

    - Non-recognition of infrastructure replacement investment between and during the pendency of general rate proceedings can delay earning a return of or on infrastructure investment for years, permanently impairing the ability to earn fair or allowed returns.

Capital Intensity:
Utility Plant / Operating Revenue



Source: AUS Utility Reports



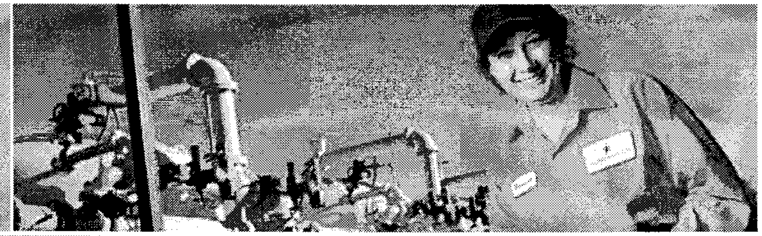
Analyst Perspectives

Negative Impact of Regulatory Lag and Potential Impact on Cost of Capital for Capital Intensive Regulated Industries

"Primarily because of regulatory lag and increased financing expenses that cause balance sheet strain and execution risks, utilities suffer sub par returns during periods of heavy capital investment."
(Source: Lehman Brothers; Power and Utilities: Regulated Utilities; Global Equity Research, North America, May 22, 2007)

Infrastructure Replacement Surcharge Programs Permit Utilities to Better Manage Cash Flows and Capital Programs in Times of Extreme Financial /Market Volatility

"Firms can also reallocate capital to projects with more timely return periods and take advantage of regulatory mechanisms that recover investment more quickly. Pennsylvania's distribution system infrastructure charge (DSIC), which allows a monthly customer surcharge for pipe repair costs, is an example of this."
(Source: Janney Montgomery Scott, LLC;Water Industry Report; October 30, 2008)



State Utility Commissions that have approved infrastructure replacement surcharges*

Pennsylvania	Delaware
Indiana	New York
Illinois	Missouri (St Louis County)
Ohio	Connecticut

*California PUC recently approved a pilot DSIC program for one of California American Water Co Districts

Examples of AW Utilities Infrastructure Replacement Programs

State/Program	Applicability	Timing/Frequency	Recovery Cap	Included Plant
Indiana Distribution System Improvement Charge **(DSIC)**	Water	Not > once every 12 month period; not in year of rate case being filed prior to DSIC filing.	5% of revenue between rate cases	Replacement & reinforcement mains, hydrants, services and meters and not included in last rate case.
Illinois Qualifying Infrastructure Plant Surcharge **(QIPS)**	Water & Wastewater	Annually (prospective plant) Quarterly (historic plant)	5% of revenue between rate cases	Water: Mains, services, meters, hydrants, and relocations and looping dead ends. Sewer: Force and gravity collection, mains, services, and manholes
Missouri (St Louis Cnty) Infrastructure System Replacement Surcharge **(ISRS)**	Water	Semi-annually Depreciation and property tax, all others have pre-tax ROR	Not in excess of 10% of previously approved revenue	Mains, valves, hydrants, main cleaning and re-lining and facility relocations

- **All Programs Reconciled Annually**

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Examples of AW Utilities Infrastructure Replacement Programs (cont'd)

State/Program	Applicability	Timing/Frequency	Recovery Cap	Included Plant
Ohio System Infrastructure Charge	Water & Wastewater	Once every 12 month period	3% per year for maximum of 3 years; limit of 3 surcharges in effect; can be reduced if it causes the company to earn an excessive rate of return on its valuation	Water: Replacement mains, valves, service lines, hydrants, main extensions, main cleaning or re-lining, unreimbursed relocation expenditures, required by a governmental agency , land or land rights related to qualifying plant. Sewer: Replacement mains and lift stations, main extensions, main cleaning I&I elimination or relining, unreimbursed facilities relocation expenditures, land or land rights needed related to qualifying plant.
Pennsylvania Distribution System Improvement Charge **(QIPS)**	Water	Quarterly	7.5% of total revenue, applicable for period between base rate cases, at which time total DSIC is folded into base rates, SSIC restarts and is set to -0-. Can be capped at a lower level if Company is earning in excess of authorized.	Replacement mains, valves, service lines, hydrants and meters.

* All Programs Reconciled Annually

AMERICAN WATER

Focus on Pennsylvania American Water

- **Total DSIC capital investment since inception in 1997:**
  - $557,000,000
- **Frequency of rate case proceedings pre DSIC:**
  - Annually
- **Frequency of rate case proceedings post DSIC:**
  - Every two years on average
- **Infrastructure replacement pre and post DSIC**
  - Pre DSIC average from 1991 to 1996 was approximately $17 million
  - Post DSIC average from 1997 to 2007 was approximately $44 million

Focus on Pennsylvania DSIC - DSIC Impact

Company # 1

Pre-DSIC Rehabilitation Pace:

- 1991 – 3.8 Miles completed; entire system would require 904 years
- 1995 – 14 Miles completed; entire system would require 246 years

Current Pace with DSIC:

- Since 1997 – 23 miles completed annually; entire system can be completed in about 125 years

(Source: Presentation of Carol Kozloff, Water Industry Policy Analyst for Commissioner Robert F. Powelson, PA PUC, to the California Water Association, May 4, 2004)

Focus on Pennsylvania DSIC - DSIC Impact

<u>Company # 2</u>

- ***Pre-DSIC (1995)***
  - DSIC-type projects - $1.2 million
- ***With DSIC (1998)***
  - DSIC investment $1.7 million
- ***Projected (2000)***
  - DSIC investment $2.5 million
- ***Projected DSIC Projects (2001)***
  - DSIC investment - $2.7 million
  - 117 years to complete entire system

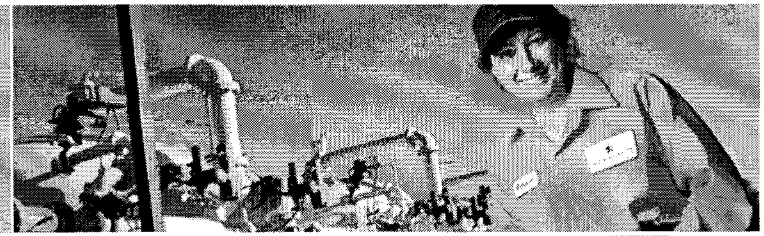
(Source: Presentation of Carol Kozloff, Water Industry Policy Analyst for Commissioner Robert F. Powelson, PA PUC, to the California Water Association, May 4, 2004)

Focus on Pennsylvania DSIC - DSIC Impact

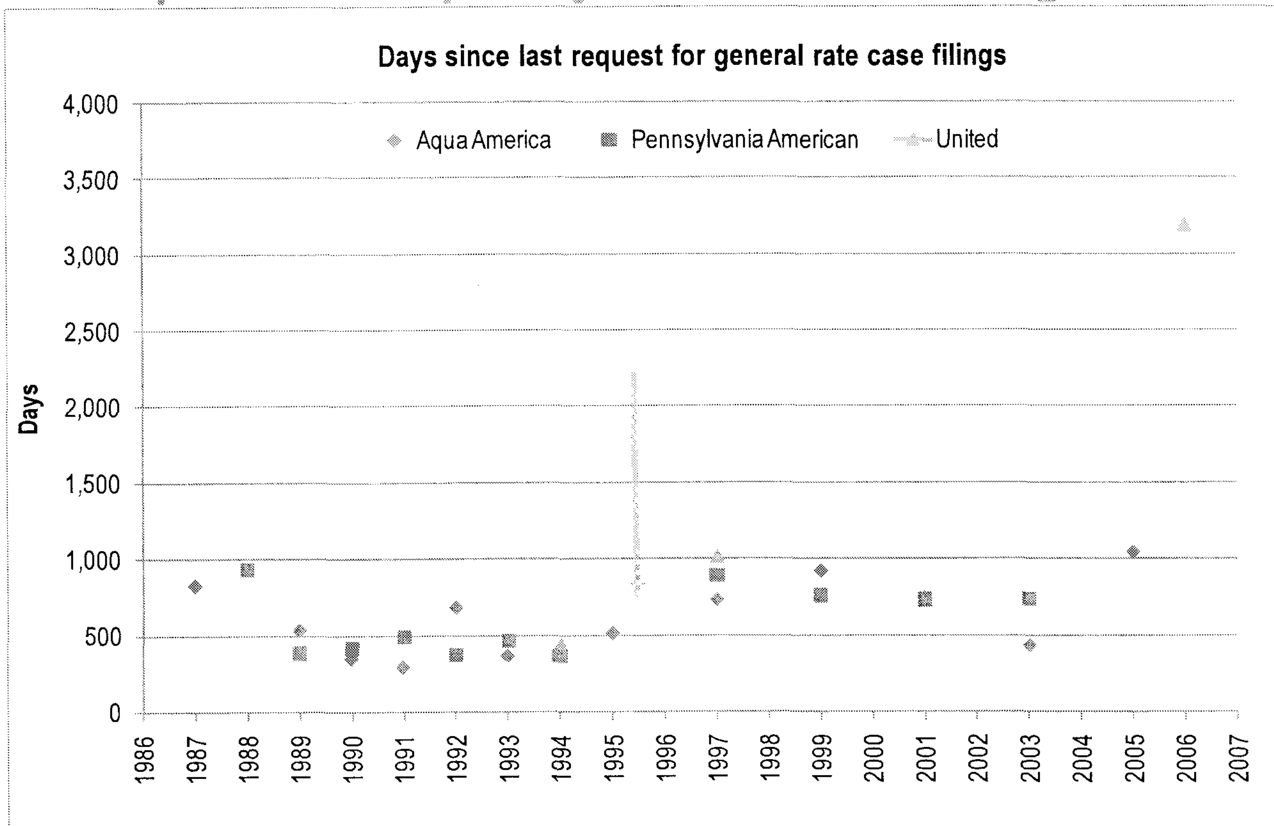
<u>Company # 3</u>

- ***Pre-DSIC***
  - System-wide improvement rate – 27 miles
  - Entire system would require 225 years
- ***First year of DSIC***
  - Replacement rate – 42 miles
  - Entire system would require 178 years
- ***Second year of DSIC***
  - *Replacement rate dropped to 163 years*
  - *Remediated 46.6 miles*

(Source: Presentation of Carol Kozloff, Water Industry Policy Analyst for Commissioner Robert F. Powelson, PA PUC, to the California Water Association, May 4, 2004)



Focus on Pennsylvania:
Potential Impact on Frequency of Rate Case Filings



(Source: Presentation of Dr. Jan Beecher, Executive Director, Institute for Public Utilities, Michigan State University, to the 2008 Eastern NARUC Water Committee Rate School)

Pennsylvania PUC Comments in Support of DSIC Increase from 5% to 7.5%

Citing page 21 of the Decision:

"The current DSIC cap of 5% will not provide the Company with resources adequate to achieve this Commission's long term objective, accelerating the replacement of aged water distribution systems throughout the Commonwealth. Increasing the DSIC cap to 7.5% would achieve a reasonable balance between supporting the Company's efforts to improve its distribution system while encouraging it to make reasonably frequent base rate filings. PAWC has used the funds available to it under the current 5% cap consistent with the legislative intent. We believe that the incremental increase in the cap to 7.5% will permit the Company to accelerate its replacement of this critical distribution infrastructure."

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Approximate Utility Plant Placed in Service Under Infrastructure Surcharge Programs

Illinois QIP (2005 - 2008)*	$ 34,568,337
Indiana (2003 - 2008)	$ 68,289,680
Missouri (2003 - 2008)	$ 143,576,508
Ohio (2005 - 2008)	$ 3,350,057
New York (2004 - 2008)	$ 10,080,000
TOTAL (without Pennsylvania)	$ 259,864,582
Pennsylvania (1997 - 2007)	$ 557,000,000
TOTAL - AW	$ 816,864,582

* Dates do not necessarily correspond to authorization of DSIC-like program because of rate case timing

DSIC Charges – Examples of Approximate Impact on Typical Customer Bill

State	DSIC MAX (% of revenues)	Typical Avg. Monthly Residential Bill	MAX DSIC Surcharge Per Month	% Current Surcharge	Current Surcharge Per Month
IL	5%	$40.33 (Peoria)	$2.02	0.00%*	$0.00
IN	5%	$30.53	$1.53	2.49%	$0.76
OH	3%/filing 3 filings between rate cases	$35.07 (Franklin Co)	$1.05 (each yr for 3 yrs)	0.00%*	$0.00
MO (St Louis Co)	10%	$21.50	$2.15	2.10%	$0.45
NY	Capped at $3 million over routine spend	$48.99	X	X	$0.35
PA	7.50%	$42.64	$3.20	2.44%	$1.04

* Surcharges worked into general rates pursuant to general rate cases

Ratepayers Protections

- Surcharges are limited to a maximum, relatively small, percentage of revenues (5% - 10%), with small impact on customer bills
- Annual reconciliations occur with refund potential to prevent any significant over recovery
- Surcharges are reset to zero at the time of a general rate case
- Surcharges are limited to specific non additional revenue producing infrastructure replacement
- Depending on the state, other provisions may apply, such as customer notice requirements, limitations to plant actually in service, etc.

As a result very few customer complaints or inquiries have been received in any state where an AW subsidiary has utilized such programs. This includes customers who may be confused or simply have questions about the program.

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Potential Benefits of a DSIC Program

- Mitigates rate shock
- Reduces rate case expense
- Reduces frequency of base rate proceedings
- Allows for more infrastructure improvements and far more efficient rates of necessary infrastructure replacement
- Promotes the acquisition of small and non-viable water systems consistent with Commission policy
- Allows for pro-active planning and related cost benefits associated with infrastructure replacement
- Positive impact on capital attraction and cost of capital
- Accelerates the replacement of aging infrastructure

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Endorsement of DSIC-Like Infrastructure Replacement Programs

- As early as February, 1999, NARUC, through a resolution, endorsed DSIC as "…an example of an innovative regulatory tool that other Public Utility Commissions may consider to solve infrastructure remediation challenges in their states."
  - Resolution adopted February 24, 1999
- NARUC recognized DSIC-like programs as a "Best Practice."
  - Resolution adopted July 27, 2005
- DSIC-like programs included as model legislation by Council of State Governments in 1999, Publications of Suggested State Legislation

Distribution System White Paper

The Potential for Health Risks from Intrusion of Contaminants into the Distribution System from Pressure Transients

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Issue Statement

This paper examines the potential for public health risks associated with intrusion of contamination into water supply distribution systems resulting from transient low or negative pressures, as well as methods for preventing intrusion of contaminants that may lead to increased health risks, and mitigation of existing contaminant intrusion problems. This problem is defined as a specialized backflow situation that occurs in an otherwise pressurized system, and therefore the reader is referred to the cross connection white paper for a broader consideration of cross connection issues, health risks, and mitigation techniques.

Definition of the Problem

A pressure transient in a drinking water pipeline is caused by an abrupt change in the velocity of water. This event is sometimes termed "surge" or "water hammer." The energy at any point in the pipeline is composed of kinetic and potential energy. Water will move through a pipe from points of higher energy to points of lower energy regardless of its position. Any change in flow in a pipe (due to valve closure, pipe fracture, or pump stoppage) will result in an exchange of energy between flow and pressure. The change in pressure can be defined by the Joukowsky equation (Thorley 1991):

$$H = \frac{4660}{\left(1 + \frac{Mw}{Mp} * \frac{ID}{th}\right)^{0.5*g}} * (Vi - Vf) \quad \text{where:}$$

H = pressure increase (ft)
Mw = bulk modulus of water (psi)
Mp = bulk modulus of pipe materials (psi)
ID = inside diameter of the pipe (in)
th = wall thickness of the pipe (in)
g = acceleration due to gravity (ft/sec^2)
Vi = initial water velocity (ft/sec)
Vf = final water velocity (ft/sec)

The magnitude of the pressure change is influenced by the materials of construction, pipe characteristics, and the water velocity. Operational characteristics can further affect the significance of pressure transients, including: non-networked and dead-end pipelines, a lack of elevated distribution system storage tanks, undulating topography, entrained air, valve characteristics, and frequent power failures of pumping stations (AWWSC 2002).

For example, consider a pipeline on which an open valve is located at a distance downstream from a reservoir. If the valve is closed instantaneously, water will decelerate to zero velocity and the kinetic energy will be converted into pressure. The transient wave will travel upstream and downstream from the valve and ultimately reach the ends of the pipe. If the pressure wave in the pipe is not relieved (as in a surge tank), it will travel in the reverse direction back to the valve. Because the valve is closed and there is no relief for this flow, a negative pressure wave (suction) will be created at the valve (Simon and Korom, 1997). This wave will travel back and forth until the kinetic energy is dissipated by friction. The process will occur both upstream and downstream from the valve. However, the initial pressure will be positive on the upstream side and negative on the downstream side (Simon and Korom, 1997).

The analysis of transient flow in large distribution systems or other incompressible fluids requires the solution of the wave equations coupled to the boundary conditions of the flow. A widely used technique is the so-called method of characteristics (Streeter and Wylie 1967) or the wave plan method (Wood et al. 1966). Pressure transients can be described as waves (Figure 1), having both a positive and negative amplitude (Simon and Korom 1997, Funk et al. 1999). Because these waves travel through the distribution system, the resulting low or negative pressures may occur in many different locations. The circumstances that produce these pressure waves may commonly occur in every water system. Pressure transients can be caused by main breaks, sudden changes in demand, uncontrolled pump starting or stopping, opening and closing of fire hydrants, power failures, air valve slam, flushing operations, fire flow, feed tank draining and other conditions including venturi effects (Funk et al. 1992). As a general rule of thumb, for every 1 ft/sec of velocity forced to a sudden stop, water pressures increase 50 to 60 psi (depending on the pipe materials, topography, etc.). The opposite is true for a sudden velocity increase, resulting in an instantaneous low or negative pressure (Kirmeyer et al. 2001).

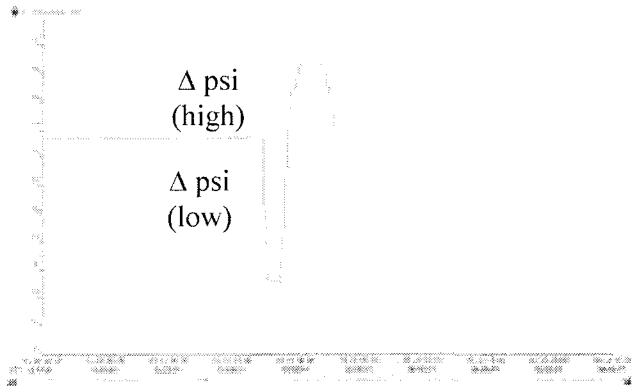


Figure 1. A Pressure Transient

The production of negative pressure transients creates the opportunity for backsiphonage or backpressure of non-potable water from domestic, industrial or institutional piping into the distribution system (USC FCCCHR 1993). These conditions of backflow are more thoroughly addressed in the cross connection white paper. Intrusion refers to the flow of non-potable water into mains though leakage points, submerged air valves, faulty seals, or other openings.

Magnitude of the Risk

The public health significance of intrusion from a pressure transient depends on the number and effective size of orifices (leaks), the type and amount of contaminant external to the distribution system, the frequency, duration, and magnitude of the pressure transient event, and the population exposed.

Pipe Leakage, Orifices, and Location

In the American Water Works Association Research Foundation (AwwaRF) report *Pathogen Intrusion into the Distribution System* (Kirmeyer et al. 2001), 77% of 26 utilities surveyed had a leak detection program that used a variety of different leak detection techniques (e.g., leakage correlator, comparison of metered sales, electronic noise detection). The percent of leakage (unaccounted for water) for these utilities ranged from less than 10 percent to as high as 32 percent. It is not uncommon for water systems to lose more than 10 percent of the total water production through leaks in the pipelines (AWWA and AwwaRF 1992). In reality it is very difficult to precisely know how much of the unaccounted water is due to leakage unless a significant effort is exerted to track all losses.

Table 1. Determination of the Intrusion Volume (in gallons) During a 30 Second Negative Pressure Event

Orifice Diameter (in.)	Power Loss		Main Break		Fire Flow	
	1 ft	10 ft	1 ft	10 ft	1 ft	10 ft
1/32	0.01	0.08	0.04	0.12	0.04	0.12
1/8	0.2	1.2	0.6	1.8	0.6	1.8
1/2	3	18	8	27	8	26
1	8	58	23	96	24	87
2	13	185	55	335	46	244

From Kirmeyer et al. 2001.
1ft and 10 ft refers to the height of the external water table above the pipe.

Hydraulic modeling can be used to estimate the impact of orifice diameter on the volume of water that could intrude during a negative pressure event (Funk et al. 1992, Funk et al. 1999, Kirmeyer et al. 2001). Depending on the effective size of the orifice, the external pressure, and the nature of the transient event, the volume of intrusion can range from milliliters to hundreds of gallons (Table 1).

Pipes located below the water table are subject to pressure from the exterior water (depending on the height of the water table above the pipe) and thus an opportunity exists where water exterior to pipe could intrude into the pipe under low or negative pressure conditions within the pipe. Utilities were surveyed as to the percentage of mains that are submerged, and the results showed that at least 20% of the systems had pipes below the water table (42% had no information) (Kirmeyer et al. 2001). It is assumed that all systems have some pipe below the water table for at least some time of the year.

Water may also intrude into a distribution system by means other than pipelines. It has been speculated that faulty joints seals may leak under certain circumstances when exposed to negative pressures (Grigory, 2002). A survey of the percentage of flooded vaults or meter boxes showed that although the rate changed seasonally, approximately 20% of the systems reported between twenty-five and seventy five percent of meter boxes flooded, with about half of the systems

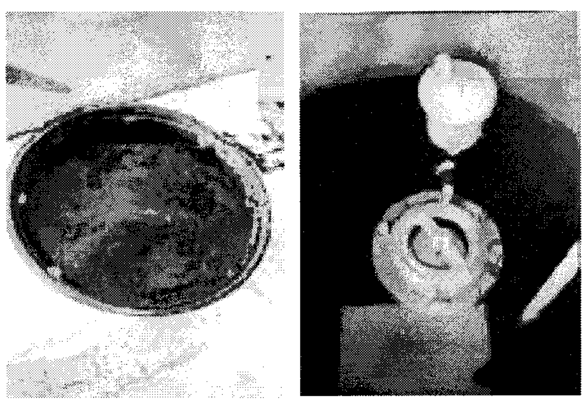


Figure 2. Submerged air release valve

not knowing how much flooding had occurred (Kirmeyer et al. 2001). One utility provided pictures of an air valve vault that was flooded with an oily film and a second picture from a short while later when the vault was drained (Figure 2). It is presumed that a pressure transient caused the air valve to open and allowed the water to enter into the distribution system. Engineering standards (Recommended Standards for Water Works 1997) specify that all air release valves (and similar appurtenances) be designed with above-grade-venting (this venting should be tamper-proof to prevent deliberate contamination of the system), or be modified in a way to prevent the flooding of the vault (e.g., via drainage or a pump).

Presence of Contaminants External to the Distribution System

Any contaminant exterior to the distribution system may enter potable water supplies during a negative pressure event. Chemical contaminants could include pesticides, petroleum products, fertilizers, solvents, detergents, pharmaceuticals, and other compounds. Predominant pesticides in urban areas include atrazine, simazine, prometon, and diazinon (Patterson and Focazio 2001). Other studies have detected insect repellants, fire retardants, and other industrial chemicals (Koplin et al. 2002). If chemical compounds intrude in sufficient concentration or volume, they might result in acute toxicity. Microbial contaminants are a concern because even with dilution, some microbes (e.g., viruses) could cause an infection with a single organism.

Karim et al. (2001) reported on a study that examined 66 soil and water samples collected from 8 utilities in 6 states. The samples were collected immediately adjacent to the drinking water pipelines. The purpose of the study was to determine the presence of microbial contaminants in the soil immediately external to the distribution system. Whenever a main was excavated, samples were collected of either the water or the undisturbed soil next to the pipe. Total coliform and fecal coliform bacteria were detected in water and soil in about half of the samples, indicating the presence of fecal contamination (Figure 3). *Bacillus* was found in almost all the samples, which is not a surprise since it is a normal soil organism. Viruses were detected using culturable methods in 12 percent of the soil and water samples, and by molecular methods in 19 percent of the soil samples and 47 percent of the water samples. When these data are combined, 56 percent of the samples were positive for viruses either in the water or the soil. Sequence analysis showed that these viruses were predominantly enteroviruses (the vaccine strain of Poliovirus), but Norwalk and Hepatitis A viruses were also detected, providing clear evidence of human fecal contamination immediately exterior to the pipe.

In the same study an analysis of the levels of organisms detected showed that they could be quite high; for example, total fecal coliform levels were as high as 10^4 bacteria per 100 grams of soil (Table 2). This may not be surprising considering that sewer lines are often located only a few feet away (Figure 4). Engineering standards call for a minimum separation of 10 ft between drinking water and sewer pipelines, although separations can be as little as 18 inches if the drinking water pipe is located at a higher elevation than the sewer pipe (Recommended Standards for Water Works 1997). In saturated soil conditions, microbes can move several meters in short periods of time (Abu-Ashour et al, 1994). This transport could be aided by water flowing out of the sewer (exfiltration).

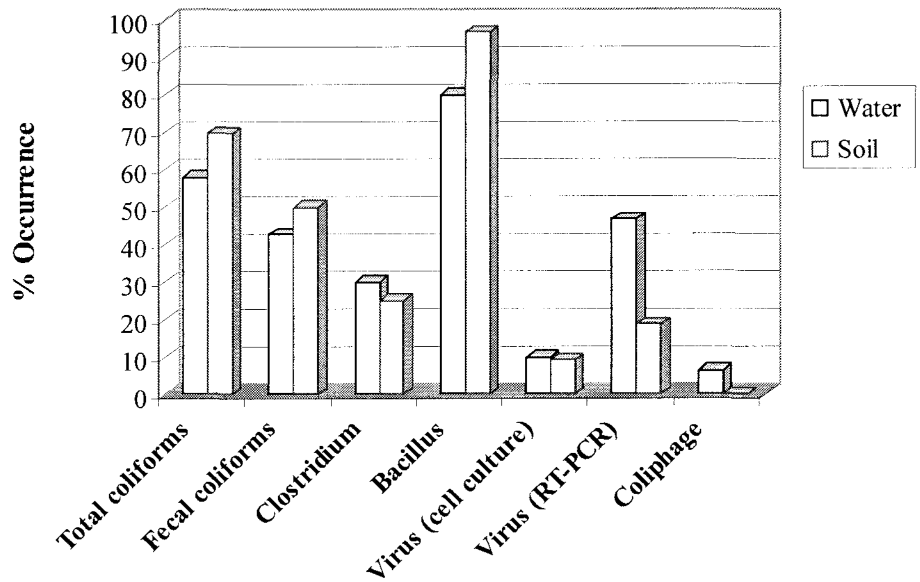


Figure 3. Summary of Microbial Occurrence in Water and Soil Samples

The soil and water samples in the study (Karim et al. 2001) were randomly collected from urban environments and the location of adjacent sewer lines is not known. More detailed studies could develop better guidelines for the separation of water and sewer mains. The concentration of *Bacillus* spores in soil was as high as 10^8 colony-forming units (CFU) per 100 grams of soil, with some of the highest levels associated with samples containing human enteric viruses. It is possible that seepage of sewage stimulated the growth of the soil flora in these locations.

Table 2. Microbe Concentration in Water and Soil

Organism	Water CFU or PFU/100 ml	Soil CFU or PFU/100 gm
Total Coliforms	$< 2 - 1.6 \times 10^3$	$< 2 - 1.6 \times 10^4$
Fecal Coliforms	$< 2 - 1.6 \times 10^3$	$< 2 - 1.6 \times 10^4$
Clostridium	$0 - 2.5 \times 10^3$	$0 - 1 \times 10^5$
Bacillus	$0 - 4.6 \times 10^6$	$0 - 1.2 \times 10^8$
Phage	$0 - 1 \times 10^4$	0

CFU, colony-forming units; PFU, plaque-forming units

Figure 4. Leaky water pipe laid next to a sewer pipe
(Source: Opflow 1999)

Frequency and Magnitude of Pressure Transient Events

Problems with low or negative pressure transients have been reported in the literature (Walski and Lutes 1994, Qaqish et al. 1995). Recent research efforts have focused on documenting the frequency and magnitude of pressure transient events to determine whether negative pressure events occur during normal distribution system operations. A high-speed pressure logger (RDL 1071L/3 Pressure Transient Logger, Radcom Technologies, Inc.; Woburn, MA), with a monitoring rate of 1-20 measurements per second and a range from 0 to 300a psi, was used to detect negative pressure events. Other manufacturers offer similar equipment.

A comparison of a high-speed electronic data logger to a conventional strip chart recorder showed a good correspondence between the measurements of sudden high pressures, but the Radcom monitor was much more sensitive for capturing the low pressure events, on average showing values 10 psi lower than those recorded by the conventional recorder (Figure 5).

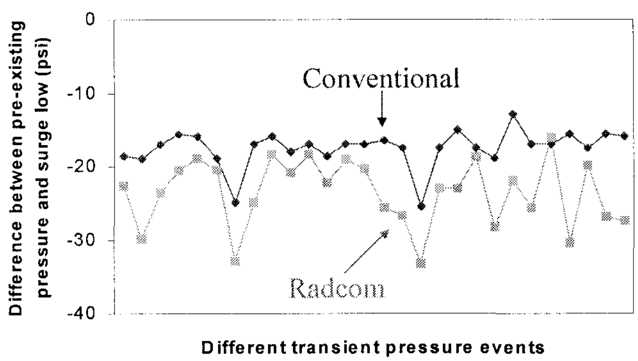


Figure 5. Comparison of the Radcom and Conventional Pressure Recorders for Measurement of Low Pressure Events

Application of high-speed pressure loggers to routine operations in approximately 10 systems has shown substantial variability in pressure values, however, negative values have only rarely been observed. Various attempts to examine hydrant flushing with different rates of valve opening demonstrated the production of pressure transients, but none of the events produced negative distribution system pressures (Kirmeyer et al. 2001). Additional investigation of hydrant operation is warranted because hydraulic modeling has suggested that negative distribution system pressures could be produced under certain hydrant flushing circumstances.

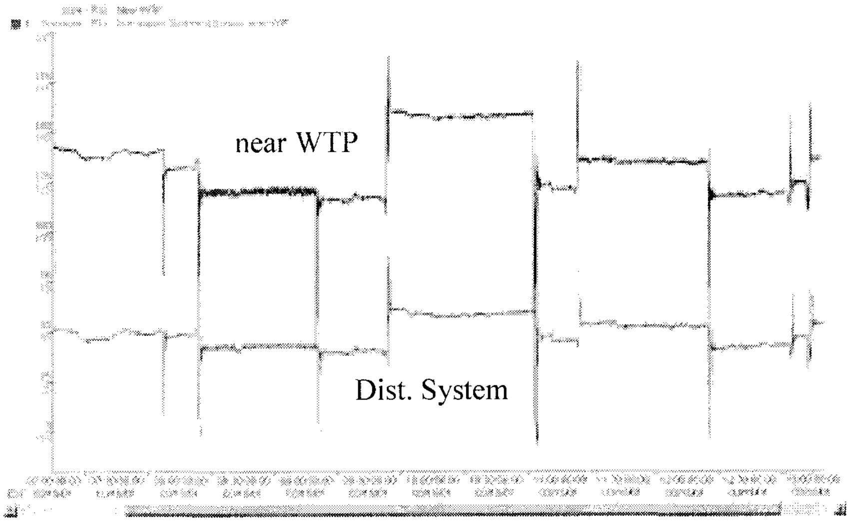
Examination of a household tap showed large fluctuations with pressures as low as 4.3 psi (data not shown). These fluctuations may be due to domestic water use patterns. If there was an external water table of 10 ft over the pipe (as in a stream crossing or low land area), there could be enough external water pressure to cause intrusion. The point is that it is not necessary to have a negative pressure – a low pressure can cause intrusion under certain circumstances.

Pressures were analyzed in one system while conducting a routine draw down test in Spring 2001 (an annual test to verify accuracy of the venturi meters at the water treatment plant). During this test, the main service pumps were shut down at the treatment plant clearwell and restarted with all flow going through one venturi meter. Two Radcom monitors were installed at high elevation points on a 30-inch main (one was ~2.5 miles from the plant, and the other was ~4.5 miles from the plant), and a third monitor was located about 80 feet from the treatment plant's high-service pumps. Pressure readings both near the treatment plant and within the distribution system showed large pressure fluctuations. While the static pressures near the plant ranged between 125 and 150 psi, the pressure transients caused by the pump shutdowns resulted in pressures as low as 18 psi in the plant effluent. However, several miles away in the distribution system these fluctuations resulted in a pressure of minus 10 psi lasting for 16 seconds (Figure 6). The valve closure speed for the main service pumps was 20 seconds, which may have been too fast, and thus contributing to the pressure transient. A second test was conducted with the valve closure speed slowed to 30 seconds, but negative pressures resulted from this second test as well.

Routine pressure monitoring of another distribution system in December 2000 showed a negative pressure event during a power outage at a pumping station that lasted for 24 seconds and produced a negative 4.4-psi (Figure 7). Similarly, a power outage at the treatment plant of another system in July 2001 produced zero pressure for 51 seconds in a section of the distribution system (Figure 8).

Based on the above information, it is concluded that transient pressure events occur in distribution systems; that these events can result in negative pressures; that negative pressures provide a potential portal for entry of non-potable water into potable water distribution pipelines; and that fecal indicators and culturable human viruses are present in the soil and groundwater exterior to the distribution system. However, the characteristics of distribution systems that contribute to producing negative pressure transients have not been examined. These characteristics may include the presence of storage tanks, valve closure speed, placement of air relief and other surge control devices, pump operation, and shut down procedures. To date, all observed negative pressure events have been related to power outages or other pump shutdowns. More research is needed to better characterize the types of systems (e.g., those without distribution storage, without air or vacuum relief valves, etc.) most prone to negative pressure transient events.

A



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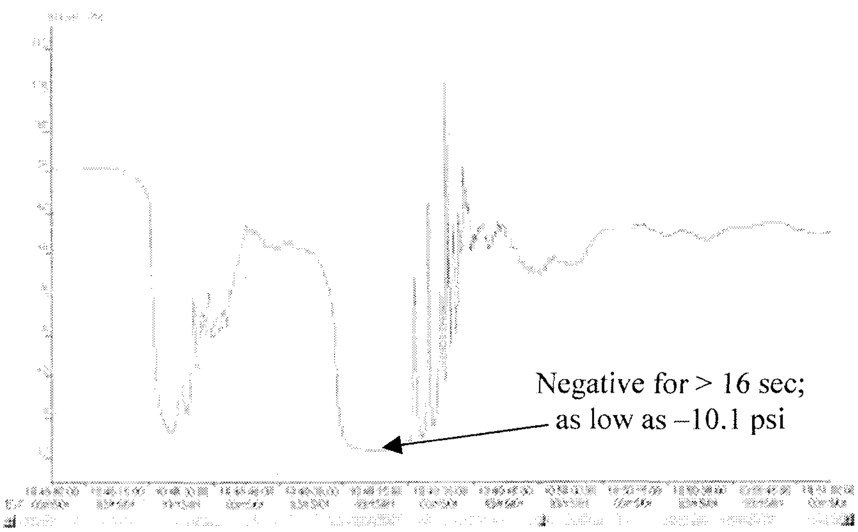
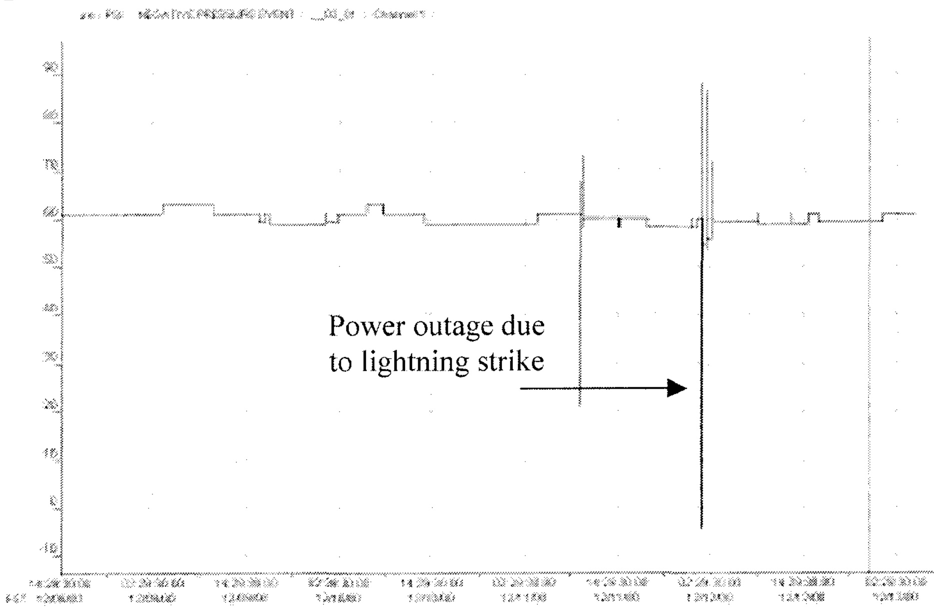


Figure 6. Pressure Recording During a Pump Draw Down Test.
A) Pressures near the water treatment plant (WTP) and in the distribution system. B) Enlargement of one of the distribution system negative pressure events shown in A, illustrating duration of the negative pressure event. A second recorder in the distribution system showed similar results.

A



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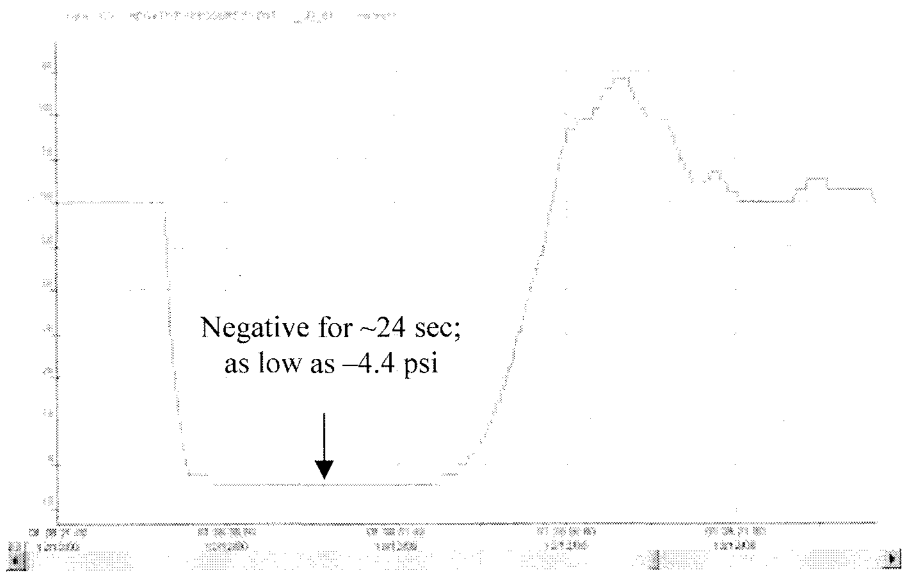
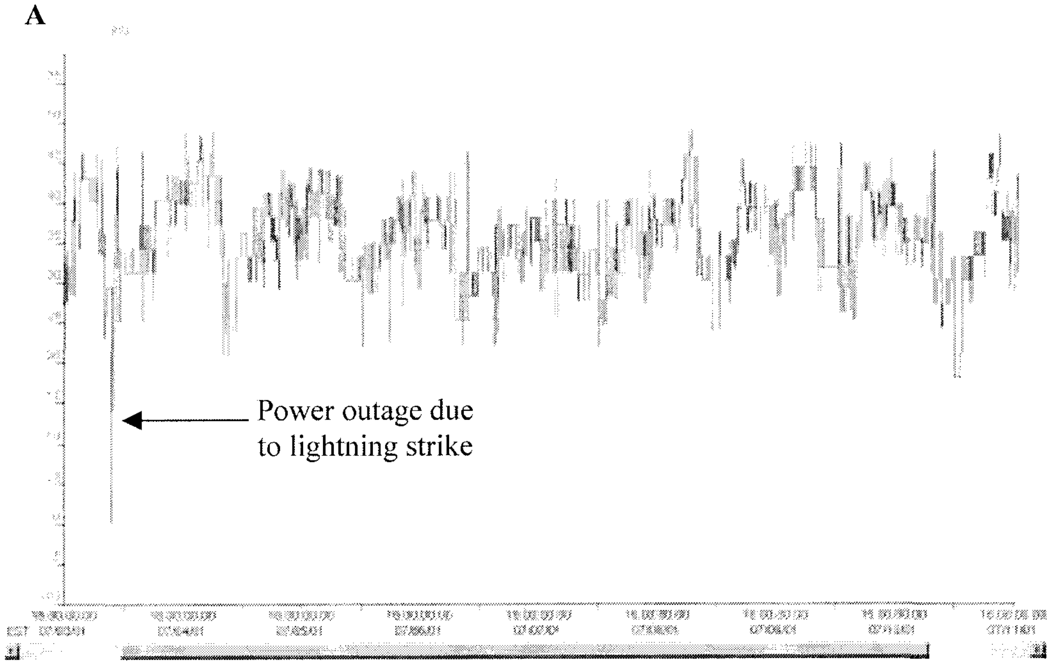


Figure 7. Distribution System Pressure Monitoring Following a Pump Station Power Outage. A) Daily monitoring data, B) Enlargement of the negative pressure event.

A



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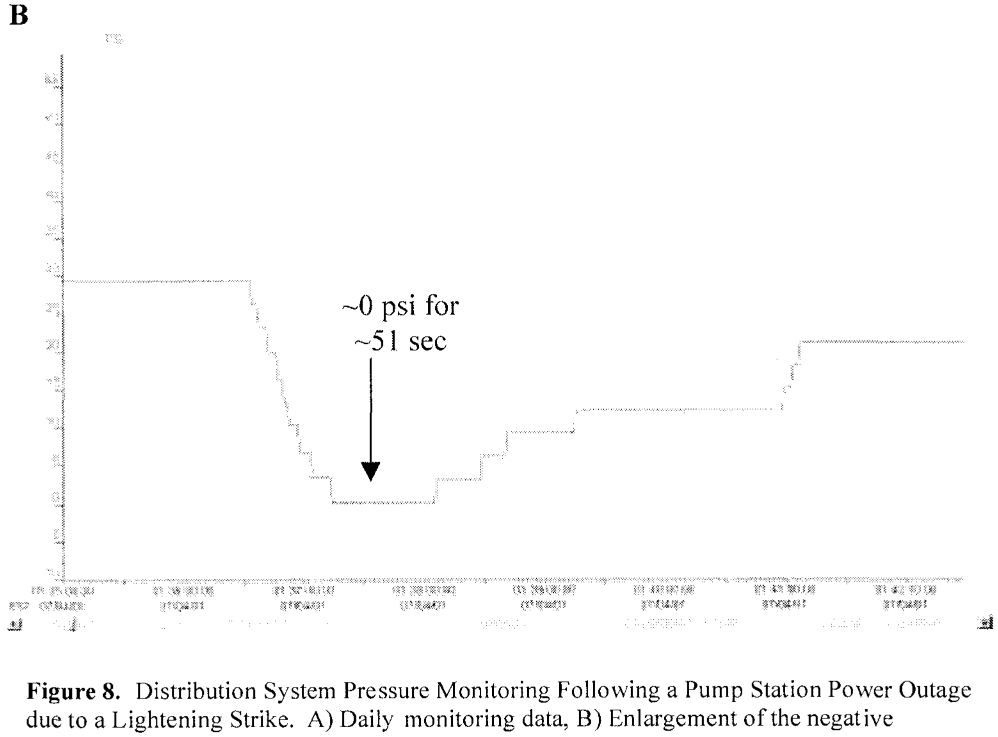

Figure 8. Distribution System Pressure Monitoring Following a Pump Station Power Outage due to a Lightening Strike. A) Daily monitoring data, B) Enlargement of the negative pressure event.

Public Health Impact

Payment et al. conducted two epidemiology studies (Payment et al, 1991; Payment et al, 1997), each suggesting that the distribution system was at least partially responsible for increased levels of gastrointestinal illnesses. The studies examined the health of people who drank tap water and compared the group to people receiving water treated by reverse osmosis to determine which group had higher levels of gastrointestinal illness. Both studies pointed to the fact that people who drank tap water had increased cases of gastroenteritis. Analysis of Payment's data shows that people who lived in zones far away from the treatment plant had the highest risk of gastroenteritis. Transient pressure modeling (Kirmeyer et al. 2001) found that the distribution system studied by Payment was extremely prone to negative pressures, with more than 90 percent of the nodes within the system drawing negative pressures under certain modeling scenarios (e.g., power outages). The system is located in the Montreal area, and reported many pipe breaks, particularly during the Fall and Winter when temperature changes place added stresses on the distribution system. Although the system employed state-of-the-art treatment, the distribution network maintained low disinfectant residuals, particularly at the ends of the system. Low disinfectant residuals and a vulnerability of the distribution system to pressure transients could account for the viral-like etiology of the illnesses observed.

A double-blinded, randomized, trial was recently completed in Melbourne, Australia, to determine the contribution of drinking water to gastroenteritis (Hellard et al. 2001). Melbourne draws its drinking water from a protected forest watershed and has an unfiltered surface water supply using only free chlorine treatment. Free chlorine levels in the distribution system ranged from 0 to 0.94 mg/L, with a median of 0.05 mg/L, and 90% of samples had < 0.20 mg/L. Total coliform bacteria were detected in 18.9% of 1,167 routine 100-mL water samples, but fecal coliform bacteria were not detected. Distribution system samples were positive for *Aeromonas* spp. (50% of 68 weekly samples), *Campylobacter* (1 occasion) and *Giardia* (2 viable samples by reverse transcriptase-polymerase chain reaction). Six hundred families were randomly assigned to receive either a real or placebo water treatment unit installed on the kitchen faucet. Real units were designed to remove viruses, bacteria, and protozoa using microfiltration and ultraviolet light treatment. Study participants completed a weekly health diary reporting gastrointestinal symptoms during the 68-week observation period. The study found that the water was not a source of measurable gastrointestinal disease (the ratio of illness between the group drinking treated water compared to the normal tap water was 0.99, with a 95% confidence interval of 0.85–1.15; $p = 0.85$). Analysis of 795 fecal specimens from participants with gastroenteritis did not reveal any difference in pathogen detection between the two groups. Pressure transient modeling of the Melbourne system has not been done and specialized pressure monitoring was not performed during the study.

The 1996 amendments to the Safe Drinking Water Act required the U.S. Centers for Disease Control and Prevention (CDC) and the U.S. Environmental Protection Agency (EPA) to conduct epidemiology studies to determine the occurrence of waterborne disease in the U.S. Dr. Jack Colford of the University of California at Berkeley School of Public Health is conducting one of these epidemiology studies in collaboration with the Iowa-American Water Company in Davenport, Iowa. The study began in November 2000, and will be completed in June 2002. The study is a randomized, triple-blinded, placebo-controlled, crossover intervention study. The intervention to be tested is household-level treatment of drinking water. The water is treated using a kitchen countertop device that treats tap water with ultraviolet light and microfiltration. Participating households have been randomly assigned to two different groups. One group received the active device and the other received an identical-looking placebo device. Half way through the study, "cross-over" will take place: active devices will be replaced with inactive devices, and inactive devices will be replaced with active devices. The participants, the study staff, and the data analysis team will be blinded to (unaware of) which group each household has been assigned throughout the study. A total of 456 households residing in Davenport, Bettendorf, Panorama Park, and Riverdale have been enrolled.

The American Water Works Association Research Foundation has funded the American Water Works Service Company to conduct a water quality study in the Davenport area in parallel to the epidemiology study. The study is conducting extensive analysis of the raw water, treatment plant performance, distribution system and household water quality. Seven pressure data loggers (one in each pressure zone) are being used to monitor distribution system pressures to determine if pressure transients are associated with any health impacts that may be observed during the epidemiology study. To date, although fluctuations in pressures have been noted, no negative pressure events have been recorded in the distribution system. Modeling of the distribution system is underway to extrapolate the pressure data to the whole pipe network.

In summary, although there are data to demonstrate that negative pressure events do occur, there are insufficient data to indicate whether these events result in substantial risk to water quality in the distribution system. Direct monitoring of drinking water would be impractical due to the transient nature of the pressure effect, the relatively small volume of intrusion water (compared to the total volume within the pipe network), and the plug flow nature (e.g., limited dispersion) of water within distribution systems. In addition, a source of microbial contamination (e.g., leaky sewer lines) must be relatively near the pipe system, and the soil must be saturated to allow for microbial transport. These factors may be important variables explaining the disparate epidemiology results and should be factored into any future epidemiological studies.

Risk Mitigation

The first step in risk mitigation for the issue of transient negative pressures in the distribution system is simply the recognition that the phenomenon does exist. Some have dismissed the issue as being not significant, too brief, or too small of a volume to be an important source of contamination. On-going studies are beginning to document the occurrence of negative transient pressure events within distribution systems, but additional research is necessary. The frequency of negative pressure transients need to be determined, as well as the characteristics of the distribution system that contribute to these events. Studies need to be conducted for ground water systems, particularly in non-disinfected systems.

Engineering standards require consideration of pressure transients for pipeline and pump design, distribution system network analysis, and valve selection and installation (Table 3). Information on transient analysis and control can be found in standard engineering texts on pump design, pipeline flow, and fluid dynamics (Karassik et al. 1976, Larock et al. 2000, Thorley 1991, Simon and Korom, 1997). Surge control, particularly control of high-pressure events, has typically

Table 3. Available Standards and Guidelines for Surge and Intrusion Mitigation

Existing Standards and Guidelines
• ANSI/AWWA C510 (Double Check Valve Backflow-Prevention Assembly)
• ANSI/AWWA C511 (Reduced-Pressure Principle Backflow-Prevention Assembly)
• ANSI/AWWA C512 (Standard for Air Release, Air/Vacuum. And Combination Air Valves for Waterworks Services)
• Recommended Standards for Water Works (10 State Standards)
• AWWA Manual M14 *Recommended Practice for Backflow Prevention and Cross-Connection Control*
• AWWA Manual M32 *Distribution Network Analysis for Water Utilities*
• AWWA Manual M36 *Water Audits and Leak Detection*
• AWWA Manual M44 *Distribution Valves: Selection, Installation, Field Testing, and Maintenance*
• AWWA Manual M51 *Air-Release, Air/Vacuum, and Combination Air Valves*

been thought of in terms of preventing pipe bursts and efforts have been directed at reducing the maximum pressures. Concerns regarding negative pressure transients and their public health implications have not received similar attention. However, mitigation measures are well described and include slow valve closure times, avoiding check valve slam, minimized resonance, air vessels, surge tanks, pressure relief valves, surge anticipation valves, air release valves, combination two-way air valves, vacuum break valves, check valves, surge suppressors, and by-pass lines with check valves. A surge tank or standpipe provides water when system pressure decreases and can also absorb pressure increases. Four common types of surge tanks include: pneumatic or closed tank, open standpipe, a feed tank with a check valve, and a bladder tank. If water is stored in the tank for long periods of time the water quality may degrade and proper operation and maintenance is required to avoid poor quality water from entering the distribution system.

Air relief valves and similar appurtenances should be designed to have above-grade venting (at least 1-ft [0.3 m] and be designed to be tamper-proof to avoid deliberate contamination of the system). All below-grade vacuum or air relief valves should be retrofitted to above-grade venting, or modified in a way to prevent the flooding of the vault (e.g., drainage or pump).

The results of these studies emphasize the need to maintain an effective disinfectant residual in all parts of the distribution system. Although the effectiveness of a residual disinfectant has been debated (Trussell 1999), critics typically question the effectiveness of a disinfectant residual to inactivate volumes of sewage mixed with drinking water (Snead et al. 1980, Payment 1999). For distribution system negative pressure events, the volume of intruded water is a fraction (much less than 1%) of the water within the pipe network, so the opportunity for effective disinfection exists. Unknown is the effect of turbidity, compounds causing a chlorine demand, and limited mixing (in a relatively plug flow condition) on the disinfection efficacy of the residual disinfectant. Chloramine residuals will be particularly ineffective for viruses that intrude into the distribution system, as the CT (disinfectant concentration multiplied by the contact time) for preformed chloramines would not be effective for enteric viruses. Studies examining the microbial risk-risk tradeoffs (e.g., disinfection effectiveness for intrusion contaminants compared to biofilms) are needed as many U.S. water suppliers continue to convert from free chlorine to chloramines due to disinfectant by-product regulations.

Efforts to reduce distribution system pipeline leakage are beneficial not only from a water conservation standpoint, but also to minimize the potential for microbial intrusion into potable water supplies. Leaks are not simply a loss of revenue for a water utility, but the leak is a potential pathway for contamination. The public health benefits of leak control should be recognized and encouraged. Repair of leaking sewer lines should similarly be a top priority, not only to minimize the occurrence of pathogens near drinking water pipelines, but to reduce these sources of contamination being transported to groundwater supplies and receiving streams, particularly under wet weather conditions.

High-speed pressure data loggers would probably benefit distribution system monitoring, as they appear to be more sensitive, particularly for low-pressure events. Additional studies are needed to examine the accuracy of the pressure transducers and determine the appropriate placement of the recorders within the distribution system. Installation of the monitors at high elevation points within the distribution system would seem reasonable, but additional work is needed to identify other useful monitoring locations. The generation of high-quality pressure data would help determine the effect of routine operational practices on distribution system pressures. This monitoring data could evaluate the impact of hydrant operations, pump start-up and shut down procedures, and valve closing speed, among others. This information should be compiled to develop standard operating procedures to minimize low-pressure surges.

Surge modeling can be used to determine the potential vulnerability of a system to negative pressures under a number of worst-case scenarios (e.g., power failure, main break, flushing, etc.). This modeling would be useful especially after addition of new pipelines, interconnections, or changes in distribution system storage or consumption patterns that may have changed original design parameters. Modeling may be able to identify zones of the distribution system most prone to negative pressure events. These areas would then be prioritized for maintenance of a disinfectant residual, leak detection and control, main replacement, and rehabilitation of nearby sewer systems. This engineering analysis can apply surge control techniques, like installation of air relief valves (above grade), surge tanks, and other activities to mitigate negative pressure events.

Personnel training with respect to hydrant and valve operations, and prevention of unauthorized or inappropriate use of hydrants or blow-offs, would be useful so that maintenance and repair crews understand the concerns regarding the potential for intrusion.

Indicators

Many States have requirements to maintain minimum distribution system pressures based on conventional pressure recorder data. It would be inappropriate, and possibly impractical to apply the same guidelines to data collected by electronic pressure loggers. Additional research is needed to evaluate new guidelines based on the frequency and duration of the event, the concentration and type of residual disinfectant, the proximity of the drinking water main to sewer lines, soil conditions and the level of the water table, and other data that still need to be collected to assess the public health significance of such events.

Additional research is needed to develop guidelines for proper placement of pressure monitors. Distribution system modeling of a power outage suggested that negative pressures may have occurred in locations other than those selected for pressure monitoring. Monitoring locations are often selected based on the availability of land, access, and electrical power or communications; not necessarily because the location is most prone to negative pressures.

Increased microbiological monitoring, particularly using existing methodologies, is not recommended because of the low probabilities of actually detecting an intrusion event. Use of continuous chlorine residual monitors may have some application, but the effectiveness of such an approach needs to be evaluated. Development of new on-line microbial monitoring techniques may have some future application, particularly those related to fiber optic or real-time analysis.

Current or Planned Research

AwwaRF has completed one project related to distribution system intrusion (Kirmeyer et al. 2001) and has another project in progress (Field-Testing of Surge Modeling Predictions to Verify Occurrence of Distribution System Intrusion, #2686). The project is anticipated to 1) verify by field and pilot measurements surge model results and illustrate how operating conditions affect the production of low or negative pressures, 2) conduct pilot test studies comparing intrusion volume estimates for various operating conditions, and 3) develop guidelines for surge modeling, pressure monitoring, and other design and operation and maintenance practices to prevent intrusion. Drafts of this report should be available in 2003.

The Microbial/Disinfection By-Product Research Council organized a workshop in 2001 to identify the research gaps that were highlighted during development of the Stage 2 M/DBP Rules (M/DBP Research Council 2002). One workgroup dealt with distribution system issues, and the committee developed several projects that addressed intrusion. The project, "Characterizing the Importance of Distribution System Intrusion Events," would define the importance of distribution system intrusion events with respect to the frequency and level of contamination. Another project, "Distribution System Operations Assessment and Guidance Manual," would assess distribution system operational practices and goals (including intrusion) to develop a guidance manual outlining best operational practices. These recommendations will be forwarded to the USEPA and AwwaRF for consideration, but funds for these have not yet been allocated.

A report developed for the National Drinking Water Advisory Committee on recommendations for the USEPA drinking water research strategy identified a number of distribution system issues, including research on intrusion, as areas requiring future research (Working Group on Drinking Water Research 2002). The report concluded that research on the frequency, causes, mitigation, and health effects of intrusion events was one of the top research needs.

Summary

In summary, it is concluded that transient pressure events occur in distribution systems; that during these negative pressure events pipeline leaks provide a potential portal for entry of groundwater into treated drinking water; and that fecal indicators and culturable human viruses are present in the soil and water exterior to the distribution system. To date, all observed negative pressure events have been related to power outages or other pump shutdowns, although more research is needed to better characterize the types of systems most prone to these events. There is insufficient data to indicate whether pressure transients are a substantial source of risk to water quality in the distribution system. Nevertheless, mitigation techniques can be implemented, principally the maintenance of an effective disinfectant residual throughout the distribution system, leak control, redesign of air relief venting, and more rigorous application of existing engineering standards. Use of high-speed pressure data loggers and surge modeling may have some merit, but understanding the effectiveness of these tools requires additional research. More research is needed and this topic should become a priority for both the USEPA and industry-funded programs.

Acknowledgement

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Waterborne outbreaks reported in the United States

Michael F. Craun, Gunther F. Craun, Rebecca L. Calderon and Michael J. Beach

ABSTRACT

Epidemic waterborne risks are discussed in this paper. Although the true incidence of waterborne illness is not reflected in the currently reported outbreak statistics, outbreak surveillance has provided information about the important waterborne pathogens, relative degrees of risk associated with water sources and treatment processes, and adequacy of regulations. Pathogens and water system deficiencies that are identified in outbreaks may also be important causes of endemic waterborne illness. In recent years, investigators have identified a large number of pathogens responsible for outbreaks, and research has focused on their sources, resistance to water disinfection, and removal from drinking water. Outbreaks in surface water systems have decreased in the recent decade, most likely due to recent regulations and improved treatment efficacy. Of increased importance, however, are outbreaks caused by the microbial contamination of water distribution systems. In order to better estimate waterborne risks in the United States, additional information is needed about the contribution of distribution system contaminants to endemic waterborne risks and undetected waterborne outbreaks, especially those associated with distribution system contaminants.

Key words | *Campylobacter*, *Cryptosporidium*, *E. coli* O157:H7, hepatitis, norovirus, *Shigella*, waterborne outbreaks

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INTRODUCTION

Waterborne disease outbreak (WBDO) statistics have been compiled in the United States since 1920. During 1920 to 1936, these data were collected by Gorman & Wolman (1939, 1948). From 1937 to 1970, WBDO statistics were collected by several Federal agencies, and various investigators have evaluated and summarized the information (Committee on Public Works 1947; Eliassen & Cummings 1948; PHS 1964; Weibel *et al.* 1964; EPA 1971; Craun & McCabe 1973; Craun *et al.* 1983; Craun 1986).

Since 1971, the US Environmental Protection Agency (EPA), Centers for Disease Control and Prevention (CDC) and Council of State and Territorial Epidemiologists have collaborated to collect information about the causes of WBDOs. In this paper, we provide a historical perspective of WBDOs reported in the United States.

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WATERBORNE OUTBREAK SURVEILLANCE SYSTEM

The WBDO surveillance program is conducted to: (1) characterize the epidemiology and etiology of WBDOs and identify important waterborne pathogens and water system deficiencies; (2) improve detection and investigation capabilities; and (3) collaborate with local, state, Federal, and international agencies on initiatives to prevent waterborne disease (Lee *et al.* 2002; Blackburn *et al.* 2004). The primary unit of analysis is an outbreak rather than an individual case of illness. State, territorial, and local public health agencies have the primary responsibility for detecting and investigating WBDOs, and these agencies voluntarily report WBDOs to the CDC. When requested, the CDC and EPA assist in outbreak investigations.

A standard reporting form is used to solicit data on the characteristics of the outbreak (e.g. dates of illness onset, duration of illness, and suspected or confirmed etiology), testing of water and patient samples, and contributory issues such as water disinfection practices and environmental factors. Information is also requested about the actual and estimated numbers of cases, hospitalizations, and fatalities. This information is evaluated and reported in WBDO surveillance summaries, which have been published biennially or annually since 1973 (CDC 1973, 1974, 1976*a*, *b*, 1977, 1979, 1980, 1981, 1982*a*, *b*, 1983, 1984, 1985; St. Louis, 1988; Levine & Craun, 1990; Herwaldt *et al.* 1991; Moore *et al.* 1993; Kramer *et al.* 1996; Levy *et al.* 1998; Barwick *et al.* 2000; Lee *et al.* 2002; Blackburn *et al.* 2004).

Outbreaks associated with drinking water, recreational water, and other types of water exposures are reported. WBDOs associated with cruise ships are not included in this surveillance system. In this paper, we consider only outbreaks associated with contaminated drinking water.

Classifying waterborne outbreaks and water systems

Outbreaks

For an event to be defined as a WBDO, two or more persons must have experienced a similar illness. This criterion is waived for single cases of laboratory-confirmed primary amebic meningoencephalitis (PAM) and for single cases of chemical poisoning if water quality data indicate contamination by the chemical (Blackburn *et al.* 2004). Waterborne pathogens of concern in the United States have multiple transmission routes, including person-to-person contact and ingestion of contaminated food. Thus, epidemiologic evidence must implicate water as the probable source of the illness.

Since 1989, WBDOs have been classified according to the strength of the evidence (Table 1) implicating water (Blackburn *et al.* 2004). The classification system ensures objectivity in the review of outbreak reports and consistency in the reported statistics as well as encouraging investigators to submit more complete information. Classification is based on epidemiologic and water quality data provided by investigators. Outbreaks without water quality data can be included in the surveillance system, but reports that lack epidemiologic data are not. A classifi-

Table 1 | Classification of investigations of waterborne outbreaks in the United States (from Blackburn *et al.* 2004)

Class	Epidemiologic data	Water-quality data
I	Adequate	Provided and adequate
	Data were provided about exposed and unexposed persons, and the relative risk or odds ratio was ≥ 2, or the p value was ≤ 0.05	Historical information or laboratory data (e.g. the history that a chlorinator malfunctioned or a water main broke, no detectable free-chlorine residual, or the presence of coliforms in the water)
II	Adequate	Not provided or inadequate (e.g. laboratory testing of water not done)
III	Provided, but limited	Provided and adequate
	Epidemiologic data were provided that did not meet the criteria for Class I, or the claim was made that ill persons had no exposures in common besides water, but no data were provided.	
IV	Provided, but limited	Not provided or inadequate

cation of I indicates that adequate epidemiologic and water quality data were reported; however, a classification of I "does not necessarily imply whether an investigation was optimally conducted" (Blackburn *et al.* 2004) or that all information requested on the reporting form was provided. Similarly, a classification of II or III should not be interpreted to mean that the investigation was inadequate. WBDOs that affect few persons are more likely to receive a classification of III rather than I because of the relatively limited sample size available for analysis. Most WBDOs have received the classification of III (44.5%) or I (42.0%). Only 10.0% of the WBDOs have received the classification of II.

By establishing guidelines to include investigations with limited epidemiologic data (3.5% were classified as IV), investigators are encouraged to report outbreaks which may have been difficult to investigate or where some of the findings may not be conclusive. This approach tends to reduce the specificity of the reported information, but it has helped identify new and unusual water quality problems (Craun *et al.* 2001).

Water systems

Public drinking water systems associated with WBDOs are identified as either community or non-community based on definitions of the Safe Drinking Water Act. A community water system serves year-round residents (an average of 25 or more persons or 15 or more service connections). Non-community systems can serve transients or non-transients. A non-transient system regularly serves at least 25 of the same persons at least six months of the year (e.g. schools, hospitals, or factories that have their own water supply). Transient systems serve persons at campgrounds, motels, gas stations, or other businesses that have their own water supply. WBDOs that occur in individual water systems (e.g. private wells) are also reported. The statistics reported in this paper also include WBDOs associated with the ingestion of water not intended for consumption, contaminated bottled water, and contamination of water or ice contaminated at its point of use (e.g. a contaminated water faucet or serving container). These WBDOs are classified as miscellaneous deficiencies.

Limitations of the surveillance data

The information pertains primarily to outbreaks, and the reported statistics do not include endemic or sporadic cases that may be waterborne. In addition, not all WBDOs are recognized and investigated and not all investigated WBDOs are reported. Since not all investigations were optimally conducted, some information (e.g. illness severity) may not be reported.

Outbreak reporting

Since WBDO surveillance is passive and reporting is voluntary, the statistics represent only a portion of the waterborne outbreaks that actually occur (Hopkins *et al.* 1985; Craun 1986; Blackburn *et al.* 2004). Blackburn *et al.* (2004) point out that the true incidence of WBDOs is markedly underestimated and studies have not been performed to assess the sensitivity of the surveillance regarding unrecognized or unreported outbreaks.

Multiple factors influence whether waterborne outbreaks are recognized and investigated. These factors include public awareness, availability of laboratory testing, requirements for reporting diseases, and resources available to local health departments for surveillance and investigation of probable outbreaks. In addition, changes in the capacity of public health agencies to detect an outbreak might influence the numbers of outbreaks reported in each state relative to other states. Thus, caution is urged in assessing trends in the occurrence of WBDOs. An increase in the number of reported WBDOs could reflect an actual increase or a change in sensitivity of surveillance practices.

Outbreaks most likely to be recognized and investigated are those of (1) acute illness characterized by a short incubation period, (2) serious illness or symptoms requiring medical treatment, and (3) recently recognized etiologies for which laboratory methods have become more sensitive or widely available (Blackburn *et al.* 2004). Increased reporting often occurs as water system deficiencies and WBDO etiologies become better recognized, often through improved state surveillance activities and laboratory capabilities (Hopkins *et al.* 1985; Frost *et al.* 1995, 1996). Recommendations for improving WBDO statistics include: (1) enhanced surveillance activities to better detect outbreaks; (2) additional laboratory support for clinical and water analyses during outbreak investigations; and (3) increased attention to potential sources of bias during investigations (Craun *et al.* 2001; Frost *et al.* 2003; Hunter *et al.* 2003).

Illness reporting

The reported cases of illness in WBDOs are primary cases, either actual or estimated. Few investigations have identified secondary cases (i.e. persons infected by contact with primary case-patients). The cases may be defined by signs and symptoms or may be confirmed by laboratory analysis of clinical specimens. Cases may be under- or over-reported in some WBDOs. For example, even though the 1993 Milwaukee cryptosporidiosis outbreak investigation was extensive (MacKenzie *et al.* 1994; Hoxie *et al.* 1998; Proctor *et al.* 1998; Naumova *et al.* 2003), outbreak-related cases may have been over estimated (Hunter & Syed 2001). However, a study of *Cryptosporidium*-specific antibody responses in children by McDonald *et al.* (2001) also suggests that infection may have been more widespread.

During the investigation it is important to recognize and take steps to control potential biases and assess their affects, especially recall bias. Recall bias may result in the reporting of more illnesses than actually occurred (Craun & Frost 2002; Craun *et al.* 2001; Cooper 1995; Hunter & Syed 2001).

WATERBORNE OUTBREAK STATISTICS

Outbreaks

During 1920 to 2002, at least 1870 outbreaks were associated with drinking water, an average of 22.5 per year. The average annual number of WBDOs ranged from a low of 11.1 during 1951–1960 to as many as 32.4 WBDOs during 1971–1980 (Figure 1). In the most recent 12-year period (1991–2002), 207 WBDOs and 433 947 illnesses were reported; slightly more WBDOs occurred in non-community water systems (42%) than either community (36%) or individual systems (22%).

Cases of illness

During 1920 to 2002, 883 806 illnesses were reported, an average of 10 648 cases per year. The average annual number of cases ranged from a low of 1249 during 1951–1960 to a high of 36 162 cases during 1991–2002 (Figure 2). In the remaining six time periods that were evaluated, an average of 4640–9331 cases was reported each year. WBDOs in community systems ranged from 247 to 5714 illnesses per outbreak, while WBDOs in non-community

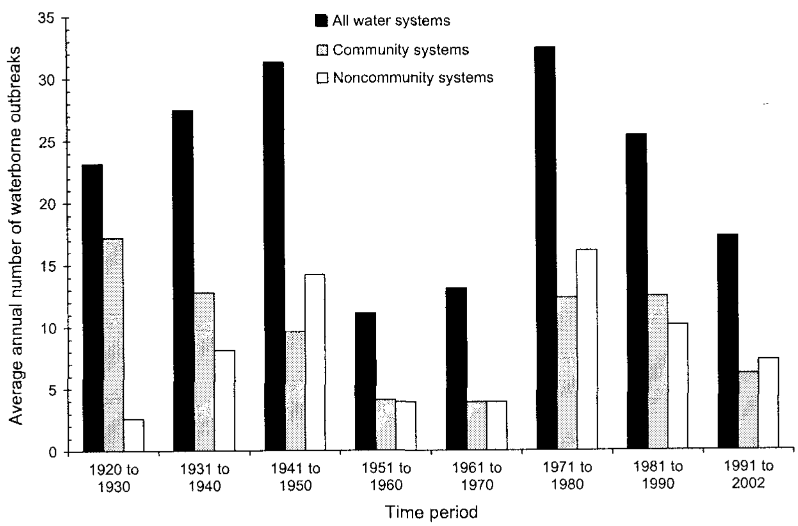

Figure 1 | Reported waterborne outbreaks, 1920 to 2002.

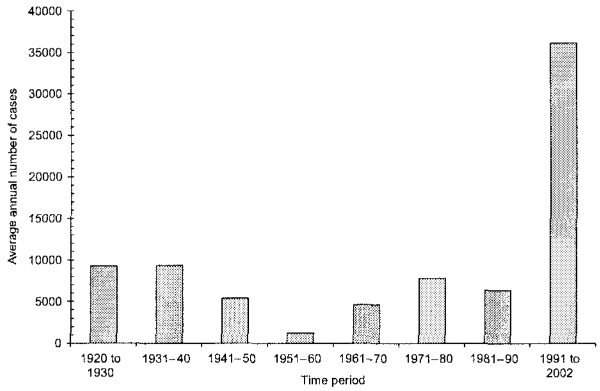

Figure 2 | Reported cases in waterborne outbreaks, 1920 to 2002.

systems ranged from 51 to 268 illnesses per outbreak (Table 2).

Fifty-eight percent of the WBDOs reported since 1971 were relatively small, resulting in 50 or fewer illnesses; only 4% of these WBDOs resulted in more than 1000 illnesses (Figure 3). The six largest WBDOs accounted for the majority (88%) of illnesses during this time period (Figure 3), demonstrating the impact that large WBDOs can have on illness statistics. The largest WBDO, an estimated 403 000 illnesses, occurred in Milwaukee in 1993.

Table 2 | Average size of waterborne outbreaks in the United States, 1920–2002

	Illnesses per outbreak		
Time period	**Community systems**	**Non-community systems**	**All systems**
1920–30	513	138	400
1931–40	748	60	339
1941–50	467	57	172
1951–60	247	51	113
1961–70	1023	111	354
1971–80	483	113	241
1981–90	289	268	250
1991–2002	5714	119	2096

Duration of illness

Information about the duration of illness was available for 40% of the WBDOs reported during 1971–2002. The mean and median of the reported duration of illness for all etiologies was 5.6 and 2.2 days, respectively; the longest reported duration was 74 days. A median duration of 6 days or less was reported in 80% of the WBDOs (Figure 4). Typically, the shortest duration of illness was found in WBDOs of a chemical or viral etiology.

Mortality

During 1920 to 2002, 1165 deaths were reported, an average of 14 deaths per year. Most deaths occurred before 1940 during WBDOs of typhoid fever (Craun 1986). During the 12-year period 1991–2002, 73 deaths (an average of 6 deaths per year) were reported (Figure 5). Fifty deaths were associated with the 1993 Milwaukee WBDO. A study of mortality during the outbreak period found that cryptosporidiosis was listed on the death certificate as the contributing cause of death for 54 persons; four cryptosporidiosis deaths were expected under normal circumstances (Hoxie *et al.* 1998). Of the 54 deaths, 46 (85%) occurred among persons whose underlying cause of death was AIDS; in 4 (7%) deaths, the underlying cause was coccidiosis. Another protozoan agent, *Naegleria fowleri* was responsible for two deaths in a single WBDO in 2002. During 1991–2002, deaths were also attributed to bacterial pathogens: seven due to *Salmonella typhimurium*, six due to *Vibrio cholerae*, non *01*, four due to *Legionella*; two deaths occurred during a WBDO caused by both *E. coli* O157:H7 and *Campylobacter jejuni*. The remaining deaths during this period occurred during WBDOs caused by excess fluoride concentration (one death) and norovirus (one death).

Hospitalizations

Information about hospital admissions was also examined for the WBDOs reported during the most recent 12-year period. During 1991–2002, illnesses in WBDOs were severe enough in 67 WBDOs for 4901 persons to be admitted to the hospital; 4400 of the hospital admissions occurred during the

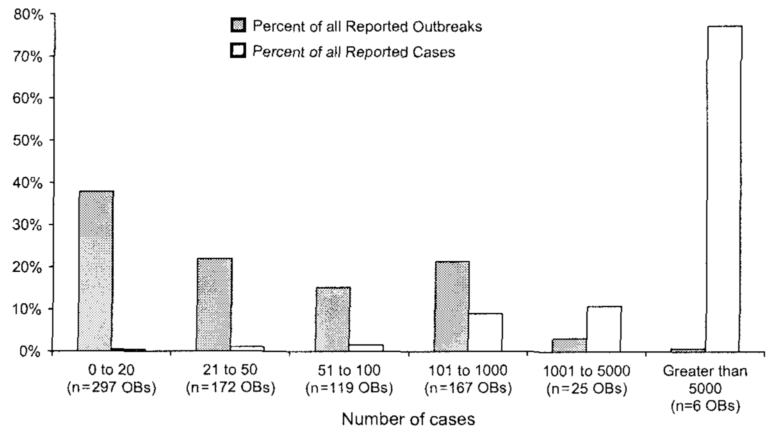

Figure 3 | Size and occurrence of reported drinking water outbreaks 1971–2002.

Milwaukee WBDO. Most WBDOs that reported hospitalizations were of a bacterial (42%) or protozoan (18%) etiology. Protozoa were responsible for most (91%) cases that required hospitalization. Nine persons were hospitalized during four viral WBDOs, and 46 persons were hospitalized during 15 WBDOs of undetermined etiology.

Water system deficiencies

Since 1971, each WBDO has been classified into one of five water system deficiency categories. We evaluated the deficiencies associated with WBDOs during 1971–2002 (Figure 6). The proportion of WBDOs reported in untreated groundwater systems has remained relatively constant since 1971. The proportion of WBDOs associated with

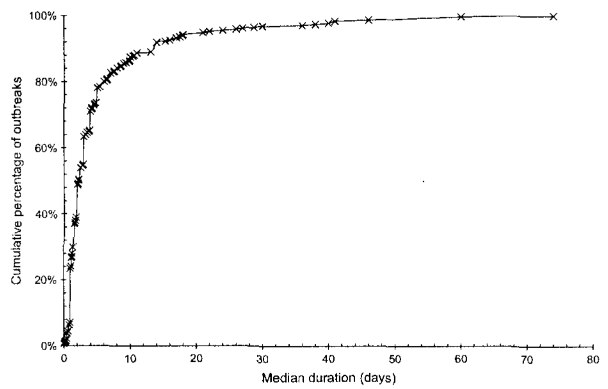

Figure 4 | Distribution of median duration of illness in waterborne outbreaks 1971–2002.

contaminated, untreated surface water has decreased since 1971, and since 1991 no WBDOs have been associated with untreated surface water systems. This is largely due to EPA rules and regulations that require the adequate treatment of public water systems using surface water.

Over the past 32 years, water treatment deficiencies have become less important as a cause of WBDOs (Figure 6). Treatment deficiencies, such as inadequate or no filtration of surface water and inadequate or interrupted disinfection of groundwater, caused 42% and 50% of all WBDOs reported during 1971–1980 and 1981–1990, respectively. However, water treatment deficiencies were responsible for 34% of WBDOs during 1991–2000 and only 14% of WBDOs during 2001–2002. This decreased importance may also reflect increased regulations and improvements in the water treatment, operation, and monitoring of surface water systems. The first WBDO caused by the inadequate treatment of surface water in a community system in over five years occurred in 2001 after the failure of a bag filtration system in a small town (Blackburn *et al.* 2004). In the previous five years, WBDOs in community surface water systems occurred in 1997 (a disinfected, unfiltered surface water system) and 1995 (a filtered surface water system). In comparison, during 1991–1994, eight community-system WBDOs were caused by inadequately treated surface water.

Water distribution system deficiencies have now become more important as a cause of WBDOs. These deficiencies were responsible for more than half of all WBDOs reported

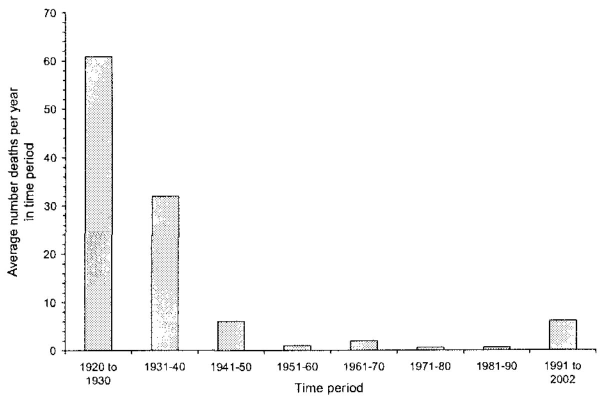

Figure 5 | Deaths associated with reported drinking water outbreaks in the United States 1920–2002.

during 2001–2002 and almost 25% of all WBDOs during 1991–2000 (Figure 6). During the 20-year period 1971–1990, these deficiencies were implicated in less than 20% of WBDOs. Distribution system-associated WBDOs tend to be small, as contamination usually affects only a portion of the distribution system, limiting the potential exposure. On average during the past 32 years, these WBDOs resulted in 152 cases per outbreak. However, five distribution system-associated WBDOs resulted in more than 1000 illnesses, with the largest causing 5000 illnesses. Although a chemical etiology is often found (35% of the WBDOs), distribution-system WBDOs are also caused by bacterial (17%), protozoan (14%), viral (4%), or undetermined (30%) pathogens.

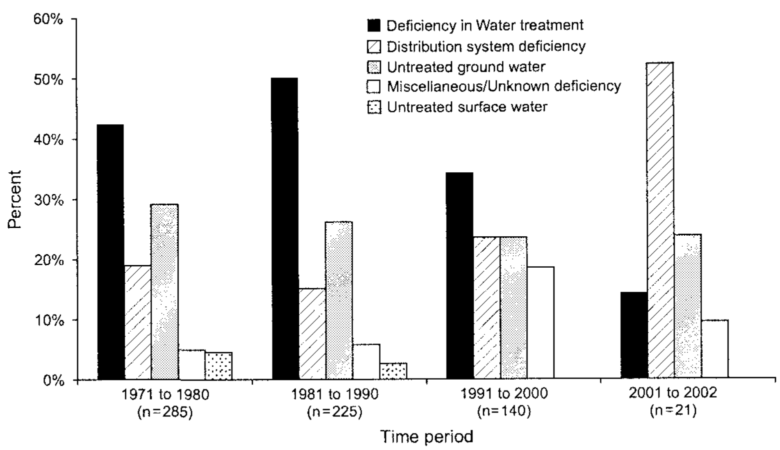

Figure 6 | Trends in system deficiencies in public water systems.

ETIOLOGY OF WATERBORNE OUTBREAKS

A historical perspective of the etiologies of reported WBDOs is provided in Figure 7. During the late 19th and early 20th centuries, cholera and typhoid were frequent causes of WBDOs in the United States. Only three WBDOs of cholera with 131 cases have been reported since 1920. Two occurred in American territories, and one occurred in a non-community system in Texas. Waterborne typhoid fever continued to occur after 1920; 70% of all WBDOs reported during 1920–1940 were attributed to *Salmonella typhi*. WBDOs of typhoid fever decreased considerably over the next 30 years to only 22% and 11% of WBDOs reported during 1941–1960 and 1961–1970, respectively. An even more dramatic decrease occurred in cases of typhoid associated with WBDOs; 87 675 typhoid cases were reported during 1920–1941 but only 108 cases occurred from 1961–1970. Since 1971, five small WBDOs occurred, and only 282 cases of typhoid fever were reported.

In spite of better laboratory methods and more thorough investigations, WBDOs classified as acute gastroenteritis (AGI) of undetermined etiology continue to be important. Usually the etiology was not determined because specimens were not collected or laboratory analyses were not available. However, in some WBDOs, the agent could not be identified even though laboratory analyses were available. During the five time periods that we analyzed, the etiology was determined in 37–73% of reported WBDOs (Figure 7). During the most recent 12 years, the etiology was determined

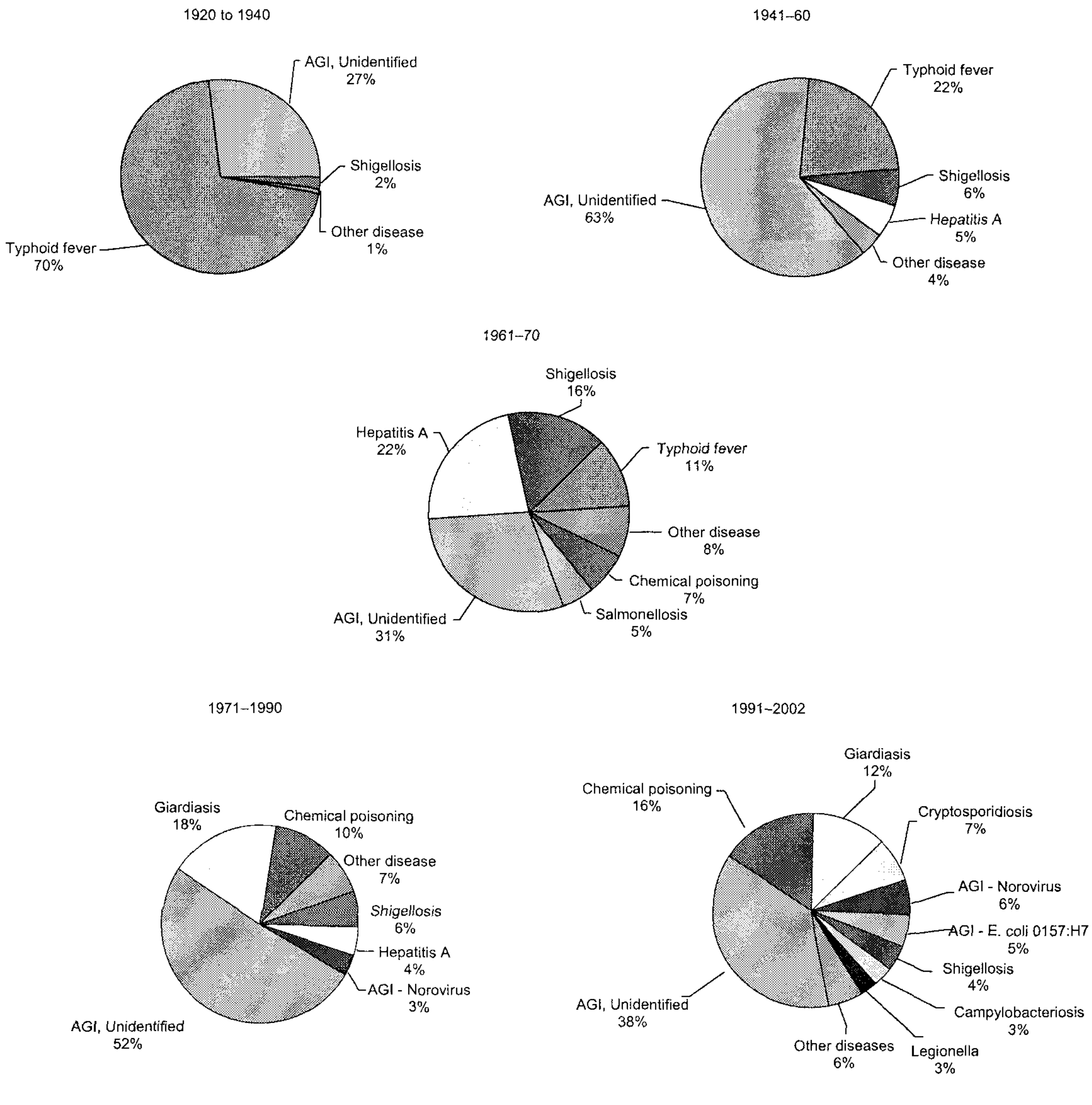

Figure 7 | Etiologies of waterborne outbreaks, 1920–2002.

in 63% of the WBDOs, an improvement over the 48% reported during the previous 20-year period 1971–1990.

Hepatitis A (22%) and *Shigella* (16%) were the two most frequently identified etiologic agents in the 1960s. During 1971–1990, WBDOs of hepatitis A (4%) and *Shigella* (6%) decreased, and the two most frequently identified etiologic agents were *Giardia* (18%) and various chemicals causing acute illness (10%). During 1991–2002, *Giardia* (16%) and chemical contaminants (12%) continued to be important, but WBDOs were caused by a number of other pathogens including *Cryptosporidium* (7%), norovirus (6%), *E. coli* O157:H7 (5%), *Campylobacter* (3%), and *Legionella* (3%).

WBDOs caused by *Legionella* species have only been tabulated since 2001 (Blackburn *et al.* 2004). *Legionella* was responsible for 6 of the 11 WBDOs associated with distribution system contamination during 2001–2002. These WBDOs occurred in large buildings or institutional settings, were related to amplification of *Legionella* in the distribution system, and mostly likely spread by aerosolization of water from the system, usually from hot water taps. In two WBDOs, *Legionella* may have entered during a mains break or back-siphonage.

Increasing numbers of waterborne pathogens have been identified as causes of WBDOs in the United States. During 1920 - 1940, only four waterborne pathogens were identified; during 1991-2002, 13 pathogens were identified (Table 3). Among the recently recognized waterborne pathogens is *Cyclospora*, which caused a single WBDO in a Chicago building that housed hospital personnel (Herwaldt *et al.* 1991). Other yet to be identified pathogens may become important. For example, two WBDOs of chronic diarrhea were reported, but no causative agent was identified even after extensive laboratory analyses (Parsonnet *et al.* 1989).

Before 1970, ten protozoan WBDOs were reported; these were primarily caused by *E. histolytica*. After 1970, 159 protozoan WBDOs were reported, primarily caused by *Giardia* and *Cryptosporidium*; only one *E. histolytica* WBDO has been reported since 1971.

DISCUSSION

Although the WBDO surveillance statistics are imperfect for estimating the incidence of epidemic waterborne illness, they can help identify important waterborne pathogens and water system deficiencies. These same pathogens and deficiencies may also be important to consider when assessing endemic risks. Surveillance information can also be used to identify changing sources of contamination and the adequacy of current treatment and regulations. If current treatment is inadequate to remove or inactivate these pathogens and if water system deficiencies that cause outbreaks are not identified and corrected, both endemic and epidemic waterborne risks are increased.

Although the number of outbreak-associated illnesses may be relatively small when compared with the possible endemic waterborne risk in the United States, illness estimates should consider the extent to which WBDOs may go unrecognized and the likelihood that one of more large WBDOs may occur in the future. The statistics for 1991-2002 are dominated by the largest WBDO since surveillance began; an estimated 403 000 persons became ill, 4400 persons were hospitalized, and 50 persons died. The concern is whether current treatment technologies, monitoring, and operational practices are adequate to remove or kill a more virulent emerging waterborne pathogen.

WBDO etiologies have changed over the years and will likely continue to change. Since 1991, 14 waterborne pathogens have caused WBDOs in the United States. The infectivity and virulence of these pathogens vary as does the host response to infection. The changing nature of waterborne pathogens suggests that other pathogens may well be important in the future. The most frequently identified etiologic agents in the last 12 years have been *Giardia* and *Cryptosporidium*, two pathogens characterized by a low infectious dose, good survival in a cold water environment, and resistance to water treatment practices that were once state-of-the art. Pathogens of emerging importance may be resistant to current water treatment practices, which have recently been upgraded to remove or kill *Giardia* and *Cryptosporidium*. WBDO surveillance can help identify changing water quality conditions and guide research strategies to ensure that treatment technologies are adequate for newly identified waterborne pathogens.

Although the mortality associated with WBDOs has decreased since 1920, an increase has occurred during the last 12 years. This increase is largely due to the 50 deaths during the Milwaukee WBDO. The underlying cause of these deaths was primarily AIDS, but the contributing cause of death was cryptosporidiosis. *Cryptosporidium* infection may lead to mild or no symptoms in some persons but to an illness of relatively long duration in others. The infection can be severe in persons with a suppressed immune system. As the population that is susceptible to severe illness or death (e.g. elderly, organ transplants, HIV infected persons, AIDS patients) becomes larger, future WBDOs may have a greater public health impact.

Since 1991, an increased proportion of WBDOs have been associated with contaminants that have entered the water distribution system. Microbial contaminants have been implicated in two-thirds of the distribution-system-associated WBDOs, and many of these pathogens are not likely to be killed by the relatively low levels of disinfectant residuals maintained in the water distribution system. These WBDOs are also among these that may frequently go unrecognized. Although these outbreaks have tended to be relatively small,

Table 3 | Etiology of waterborne outbreaks reported in the United States, 1991–2002

Etiological agent	Outbreaks	Cases
AGI	77	16 036
Chemical	33	577
Giardia	25	2283
Cryptosporidium	15	408 371
Norovirus	12	3361
E. coli O157:H7	11	288
Shigella	9	663
Campylobacter jejuni	7	360
Legionella	6	80
Salmonella, non-Typhoid	3	833
V. cholerae	2	114
Hepatitis A	2	56
Naegleria fowleri	1	2
Plesiomonas shigelloides	1	60
Campylobacter and *Yersinia*	1	12
E. coli O157:H7 & *Campylobacter*	1	781
Unidentified SRSV	1	70
Total	207	433947

several recent distribution-system-associated WBDOs have resulted in a large number of illnesses. A better understanding is needed of the extent to which these WBDOs are detected and the importance of distribution system contamination for endemic waterborne risks.

CONCLUSIONS AND RECOMMENDATIONS

WBDO surveillance statistics have been helpful in evaluating the adequacy of current technologies and regulations and identifying the relative degrees of risk associated with source waters, types of systems, and treatment processes. Even though the WBDO surveillance data have inherent limitations and represent only a portion of the actual occurrence of WBDOs in the United States, a national estimate of drinking waterborne disease risks should consider both endemic and epidemic illness.

An estimate of the number of illnesses that may be associated with WBDOs should consider the extent to which WBDOs and associated illnesses are not being recognized and reported. Contamination of the distribution system has become increasingly important as a cause of WBDOs, and unless surveillance systems are designed to specifically detect these outbreaks, a large number may go unreported.

Few studies that have attempted to estimate the extent to which WBDOs are under-reported, and research should be conducted to help assess the sensitivity of current surveillance to detect outbreaks and the extent to which WBDOs and associated illnesses may be under-reported.

Waterborne pathogens that cause WBDOs should be considered when assessing endemic risks. These pathogens may also be important causes of endemic waterborne illness. Epidemiologic studies should evaluate the endemic waterborne risks associated with the most frequently identified agents. Many WBDOs continue to be classified as AGI of undetermined etiology, and additional resources and efforts should be made available during outbreak investigations to identify the etiology. These efforts may lead to better information about important waterborne pathogens for both outbreak and endemic risks.

WBDO surveillance data indicate that measures of disease severity, such as duration of illness, are important for risk managers to consider in the national estimate of endemic waterborne illness. By considering specific infectious diseases (e.g. cryptosporidiosis, shigellosis) in additional epidemiologic studies of endemic risks, the severity of endemic illness can be better evaluated. WBDO investigators are also encouraged to collect additional information about disease severity (e.g. physician visits, age distribution of cases).

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DISCLAIMER

The views expressed in this paper are those of the individual authors and do not necessarily reflect the views and policies of the U.S. Environmental Protection Agency or the Centers for Disease Control and Prevention. The paper has been subject to the Environmental Protection Agency's peer review and approved for publication.

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Breaks and maintenance work in the water distribution systems and gastrointestinal illness: a cohort study

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Background During maintenance work or breaks on the water distribution system, water pressure occasionally will be reduced. This may lead to intrusion of polluted water—either at the place of repair or through cracks or leaks elsewhere in the distribution system. The objective of this study was to assess whether breaks or maintenance work in the water distribution system with presumed loss of water pressure was associated with an increased risk of gastrointestinal illness among recipients.

Methods We conducted a cohort study among recipients of water from seven waterworks in Norway during 2003–04. One week after an episode of mains breaks or maintenance work on the water distribution system, the exposed and unexposed households were interviewed about gastrointestinal illness in the week following the episode.

Results During the 1-week period after the episode, 12.7% of the exposed households reported gastrointestinal illness in the household, compared with 8.0% in the unexposed households [risk ratio (RR) 1.58, 95% confidence interval (CI): 1.1, 2.3]. The risk was highest in households with higher average water consumption. The attributable fraction among the exposed households was 37% in the week following exposure.

Conclusion Our results show that breaks and maintenance work in the water distribution systems caused an increased risk of gastrointestinal illness among water recipients. Better data on the occurrence of low-pressure episodes and improved registration of mains breaks and maintenance work on the water distribution network are needed in order to assess the public health burden of contamination of drinking water within the distribution network.

Keywords Drinking water, gastrointestinal illness, waterborne, water pressure, water distribution

Introduction

For the last decades, the main emphasis on preventing waterborne illness in industrialized countries has been on upgrading water treatment plants, improving source water protection and improving regulations of the water supply. In this area, there has been a great progress in improving the quality of water leaving the treatment plant. Increasingly, concern has been raised on contamination occurring within the distribution system. This can occur through cross-connections, contaminated storage facilities, backflow and during low and

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negative pressure incidents. There are many causes of pressure transients, such as turning on and off a pump, opening and closing valves, power failures, flushing of the network, fire fighting and anything that causes a sudden change in demand. Mains breaks, maintenance work and repair can cause loss of water pressure lasting for hours. Studies performed in the United States have shown that low-pressure incidents in otherwise satisfactory water distribution pipes can cause aspiration of microorganisms from the surrounding soil.[1]

In recent years, a substantial proportion of waterborne outbreaks have been attributed to failures in the distribution system. Distribution system deficiencies accounted for 36% (17/47) of waterborne outbreaks in community water systems reported in the United Staes during 1991–98[2] and this increased to 50% (9/18) during 1999–2002.[3,4] Since these outbreaks often affect a smaller proportion of the population, they may be more difficult to detect. Fewer outbreaks caused by source water contamination or failure in disinfection may also have contributed to the relative increase.

To our knowledge, there have been no studies conducted on the association between breaks or maintenance work in the water distribution system and incidence of gastrointestinal illness in the community. The primary objective of the present study was to assess the association between mains breaks or maintenance work in the water distribution system with presumed pressure loss and gastrointestinal illness among recipients the following week. The secondary objective was to investigate if some factors related to the episodes, such as weather conditions or measures to prevent contamination, were associated with an increased or decreased risk in the affected households.

Methods

We conducted a cohort-study among recipients of water from seven larger waterworks in urban areas in Norway during a 1-year period starting on September 15, 2003. The waterworks each serve between 35 000 and 460 000 people, with a total of around 1 100 000 people.

Power

With a sample of 600 exposed and 600 unexposed households and estimated frequency of households with gastrointestinal illness of 4% among unexposed households during a 1-week period, we estimated that the study had a power of 80% to detect a risk ratio (RR) of 2 given a two-sided alpha-level of 0.05.

Selection of episodes

Each waterwork was asked to identify up to two low-pressure episodes per month in the 1-year period. A low-pressure episode was defined as an incident where a part of the water distribution network was closed off due to mains breaks or maintenance work with presumed loss of water pressure in the distribution system. The episodes were either planned, i.e. related to routine maintenance work, or unplanned, i.e. caused by spontaneous pipe-breakage or accidents during construction work. The waterworks were asked to select the first planned and the first unplanned episode occurring each month that affected at least 10 households. For each episode, the following information was registered: time and place, climatic conditions, reason for the low-pressure episode, measures taken to prevent contamination, location of sewage pipe in relation to water pipeline and the water work personnel's own evaluation of the risk of contamination.

Selection of households

For each episode, the waterworks selected 10 exposed households at random from the customer register among all households affected by the low-pressure episode. Ten unexposed households were selected at random from the customer register among unaffected households in the same area as the exposed household. In a letter to all selected households, we informed them about the study and that they would be contacted by telephone and asked to participate in the study. The same information-letter and questionnaire were used both for the exposed and the unexposed households so as not to reveal the household's exposure status.

Interviewers who were unaware of the households' exposure status interviewed one person (>16 years) in both the exposed and unexposed households 8–14 days after the episode using a standard questionnaire and an interview guide. The households were informed about the interview by letter at the time of the episode, so the interviewee could prepare to answer the questions on behalf of all household members. The following information was collected: age and gender of all household members, average tap water-intake at home per person in the household, any travel abroad within the last month, children in day-care centre, employment in kindergarten, pets in the household or other regular animal contact. In addition, they were asked if they had noticed any discolouration or strange taste of the tap water within the last 14 days, or if they thought there had been any work done on the water pipes recently.

The person interviewed was also asked if there had been any episodes of acute gastrointestinal illness in the household during the week after a certain date that corresponded to the low-pressure episode for exposed households ('the observation period'). An episode of gastrointestinal illness was defined as an episode of vomiting and/or diarrhoea with at least three loose stools during a 24-h time-period. Information about age, gender and symptoms of acute gastrointestinal illness of all household members was collected at the individual level.

Ethics, data handling and analysis

The study was reviewed and approved by the Regional Committee for Medical Research Ethics.

We entered and analysed data with Microsoft Office Excel (Microsoft Corporation) and STATA 8.0 (Stata Corporation, College Station, TX, USA).

The main analysis was conducted at the household level. A case household was defined as a household with at least one person with an episode of gastrointestinal illness during the observation period. We estimated the attack rate of gastrointestinal illness among exposed and unexposed households, respectively, the RR and the risk difference with

95% confidence intervals (CI). The attributable proportion among the exposed households was computed according to method described by Rothman.[5] Stratified analyses with calculation of Mantel–Haenszel adjusted RRs were performed in order to assess possible confounders. Interaction was assessed by the likelihood-ratio test between logistic models with and without the interaction term.

To include the effect of household clustering and possibly secondary transmission within households, a second analysis was conducted on the individual level where we calculated attack rates stratified by age and gender among exposed and unexposed household members. To account for the effect of household clustering we used the xtlogit procedure in STATA with household as the panel ID variable.

We assessed possible effect modifiers in a separate logistic regression model in the exposed group of households only. Variables with P-value <0.2 were evaluated in the model. The final model retained all variables with P-value <0.1.

Results

Description of study material

A total of 88 low-pressure episodes were included in the study, varying from 2 to 24 per waterworks. The main reasons for not including more episodes were lack of interviewing capacity or lack of episodes. Mains breaks or leaks were the most commonly reported causes of the registered episodes, accounting for 63% (55/88). Change of equipment (valves, pipes, etc.) accounted for 26% (23/88) and other causes such as cleaning of pipes, construction work close to the water pipes, defective valves, etc. accounted for the last 11% (10/88). Fifty of the episodes were not planned, of which 48 were caused by leaks or mains breaks. The water was shut off for an average of 6.6 h per episode (median 5 h, range 1–33.5 h). In almost half (47%), the water shut-off was limited to ordinary working hours (0800–1600).

Only one waterworks chlorinated the affected section of the pipe after work/repair and this was done in 12 of the 14 episodes registered by this waterworks. Flushing was done in 77 (87%) of the episodes. Boiling advice to the recipients was not given in any of the reported episodes. Water samples were obtained in only 18 of 62 episodes where this information was given (29%) and only one sample was positive for *Escherichia coli*.

The total number of affected households in the 88 episodes was 5935, with an average of 67 households per episode (Table 1).

A total of 616 exposed and 549 unexposed households were interviewed in the 88 episodes, thereby giving a response rate of 70% (616/880) and 62% (549/880), respectively. The main reasons for dropout were inability to reach the households by telephone (37%), that they had moved or that the phone number could not be obtained (21%), or that they declined to participate in the study (20%). For 15%, the reason for non-participation was not given. Four exposed and two unexposed households were excluded because they could not time their gastrointestinal illness in relation to the episode.

The exposed and unexposed households were similar with respect to known risk factors investigated (Table 2).

Table 1 Number of low pressure episodes included in the study, total number of households exposed by these low pressure episodes, and number of exposed and unexposed households interviewed in the study

Waterwork	Low pressure episodes	Total number of exposed households	Exposed households interviewed	Unexposed households interviewed	Total number of interviewed households
A	24	2191	108	90	198
B	4	144	32	32	64
C	14	735	119	113	232
D	2	59	15	13	28
E	11	253	59	38	97
F	15	695	135	124	259
G	18	1858	144	137	281
Total	88	5935	612	547	1159

Table 2 Baseline characteristics of interviewed households exposed to a low-pressure episode ($n=612$) and unexposed households ($n=547$)

	Exposed households	Unexposed households	P-value*
Average number of people in household	2.3	2.3	0.94
Average age among household members (years)	37.4	37.9	0.55
Child in kindergarten	13%	14%	0.94
Family member employed in kindergarten	4%	7%	0.02
Animal contact	34%	33%	0.75
Person travelling abroad	19%	15%	0.11
Average water consumption >1 glass water per person per day	83%	83%	0.75

*t-test or chi-square test.

Table 3 Attack rate (AR) and attack risk ratio (RR) of acute gastrointestinal illness in households exposed to breaks/maintenance work on water distribution system vs unexposed households, stratified by some possible confounders, effect modifiers and factors possibly causing information bias

	Exposed			Unexposed				
Household level	Households with illness	Total number of households	AR (%)	Households with illness	Total number of households	AR (%)	RR	95% CI
Crude	78	612	12.7	44	547	8.0	1.58	1.1, 2.3
Households with member employed in kindergarten								
Yes	5	23	21.7	2	39	5.1	4.24	0.9, 20.1
No	72	588	12.2	42	508	8.3	1.48	1.0, 2.1
Test of homogeneity (M–H)							$P = 0.20$	
Mantel–Haenszel adjusted RR							1.57	1.1, 2.2
Households with person travelling abroad								
Yes	14	115	12.2	8	83	9.6	1.26	0.6, 2.9
No	62	494	12.6	36	462	7.8	1.61	1.1, 2.4
Test of homogeneity (M–H)							$P = 0.60$	
Mantel–Haenszel adjusted RR							1.54	1.1, 2.2
Households believe there has been work/repair of water mains last two weeks								
Yes	62	462	13.4	14	138	10.1	1.32	0.8, 2.3
No	16	150	10.7	30	409	7.3	1.45	0.8, 2.6
Test of homogeneity (M–H)							$P = 0.82$	
Mantel–Haenszel adjusted RR							1.38	0.9, 2.1
Households noticed discolouration of tap water last two weeks								
Yes	32	179	17.9	6	40	15.0	1.19	0.5, 2.7
No	45	430	10.5	37	504	7.3	1.43	0.9, 2.2
Test of homogeneity (M–H)							$P = 0.70$	
Mantel–Haenszel adjusted RR							1.37	0.9, 2.0
Households noticed bad taste of tap water last two weeks								
Yes	7	23	30.4	5	23	21.7	1.40	0.5, 3.8
No	66	571	11.6	38	512	7.4	1.56	1.1, 2.3
Test of homogeneity (M–H)							$P = 0.84$	
Mantel–Haenszel adjusted RR							1.54	1.1, 2.2
Season								
Winter (Dec–Feb)	26	191	13.6	15	184	8.2	1.67	0.91
Spring (Mar–May)	15	136	11.0	12	127	9.4	1.17	0.57
Summer (Jun–Aug)	9	77	11.7	4	66	6.1	1.93	0.62
Fall (Sep–Nov)	28	208	13.5	13	170	7.6	1.76	0.94
Test of homogeneity (M–H)							$P = 0.65$	
Mantel–Haenszel adjusted RR							1.60	1.1, 2.3

Analysis of gastrointestinal illness

During the observation period after the registered episode, 12.7% of the exposed households reported gastrointestinal illness in the household, compared with 8.0% in the unexposed households (Table 3). The RR was 1.58 (95% CI: 1.1, 2.3) and the risk difference 4.7% (95% CI: 1.2, 8.2). The attributable fraction among the exposed households was 37%. Stratified analysis for foreign travel or employee in kindergarten did not change the crude estimate (Table 3). The RR calculated for each waterworks varied between 1.3 and 2.2 for five of the waterworks. For the waterworks that routinely chlorinated, the RR was 1.1 and for the last waterwork, only two episodes were included, giving a very imprecise estimate ($RR = 0.9$, 95% CI: 0.1, 5.3).

Three quarters of exposed households believed there had been work/repair on water pipes vs 25% among unexposed households ($P < 0.001$). To assess information bias regarding non-blinding of the exposure, we conducted stratified analysis on whether the households thought there had been work/repair done on the water distribution system; whether they noticed discolouration or bad taste of the tap water. The Mantel–Haenszel adjusted RRs were 1.38, 1.37 and 1.54, respectively (Table 3).

The proportion of households reporting gastrointestinal illness was highest in the winter months (10.9%; 41/375) and lowest

Table 4 Risk of acute gastroenteritis in the household stratified by exposure to breaks/maintenance work on water distribution system and on average amount of daily water consumption per person in the household

	Households with illness	Total number of households	Attack rate (%)	Risk Ratio	95% CI
Exposed to breaks/maintenance					
>1 glass water	75	510	14.7	4.9	1.6, 15.2
⩽1 glass water	3	100	3.0	ref	
Not exposed to breaks/maintenance					
>1 glass water	37	452	8.2	1.1	0.5, 2.4
⩽1 glass water	7	95	7.4	ref	

in the summer months (9.1%; 13/143). Stratified analysis by season did not change the crude estimate of the RR (Table 3) and there was no strong interaction (likelihood-ratio test of interaction $P = 0.82$)

In the exposed households, a higher average daily water consumption (>1 glass water per person per day) was strongly associated with gastrointestinal illness compared with a lower average daily water consumption (⩽1 glass water per person per day) (RR = 4.9, 95% CI: 1.6, 15.2). In the unexposed households, the amount of water consumed was not strongly associated with gastrointestinal illness (RR = 1.1, 95% CI: 0.5, 2.4) (Table 4). The analysis for interaction showed a strong positive interaction between exposure and amount of water consumed in the household ($P = 0.029$).

The interviewed households included a total of 3020 household members. The attack rate of gastrointestinal illness during the observation period after break/maintenance work of the water mains was 7.5% and 3.9% in the exposed and unexposed households, respectively, giving an odds ratio of 2.0. The highest attack rate was in the youngest children (0–5 years) in both the exposed and unexposed households; however, the highest RR was observed in adults 20–39 years, where the attack rate was 10.2% and 1.8% among exposed and unexposed, respectively (Table 5).

Clinical symptoms and medical care was similar in the exposed and unexposed households (Table 6). The median duration of illness was 2 days. Twenty-three per cent had to stay away from work or school, with a median of 2 days absent.

Factors influencing the risk of illness associated with pipe breaks/maintenance work

The following factors seemed to increase the risk in exposed households: cleaning pipes by swabbing, rain during break or maintenance work and longer duration of water shut-off (Table 7). Flushing the water pipes and use of chlorination indicated a decreased risk. Only flushing the pipes, use of chlorination and duration of water shut-off had a P-value <0.1 in the multivariate logistic regression model.

The water work personnel conducting the work on the water mains were asked to make an evaluation of the risk of contaminated water reaching the consumer and classify into low, medium and high risk. None of the episodes were classified as high-risk and only seven were classified as medium risk (8.8%). The episodes classified as medium risk

Table 5 Risk of acute gastroenteritis among household members in households exposed to breaks/maintenance work on water distribution system vs unexposed households stratified by gender and age-groups

	Exposed		Non-exposed			
	Ill/total	Attack rate (%)	Ill/total	Attack rate (%)	Odds ratio[a]	95% CI
Total	120/1597	7.5	55/1423	3.9	2.0	1.3, 3.2
Gender						
Male	58/780	7.4	24/689	3.5	2.3	1.3, 3.9
Female	62/817	7.6	31/734	4.2	1.9	1.1, 3.2
Age (years)						
0–5	22/124	17.7	11/109	10.0	2.3	0.9, 6.0
6–19	25/338	7.4	10/294	3.4	2.4	1.1, 5.4
20–39	40/391	10.2	6/328	1.8	7.2	2.8, 18.7
40–69	28/575	4.9	25/538	4.7	1.1	0.6, 1.8
70+	5/164	3.1	3/148	2.0	1.5	0.3, 6.8

[a] Adjusted for the effect of household clustering.

Table 6 Symptoms and treatment among ill household members exposed to low-pressure episodes associated with breaks/maintenance work on water distribution system vs unexposed

	Exposed ($n = 120$)		Unexposed ($n = 55$)	
Diarrhoea	101	84%	46	84%
Vomiting	38	32%	22	40%
Diarrhoea and vomiting	20	17%	13	24%
Absent school/work	26	22%	13	24%
Contacted health care	4	3%	3	5%
Faecal sample	0	0%	1	2%
	Median	**Range**	**Median**	**Range**
Age	32	1–95	40	1–87
Duration of illness in days	2	1–14	2	1–14
Days absent school/work	2	1–5	2	1–5

were associated with a higher risk of illness than episodes classified as low risk (RR = 1.8; 95% CI: 1.0, 3.2).

Discussion

We have found an increased risk of acute gastrointestinal illness in households affected by work on the water distribution network with presumed pressure loss. The risk of experiencing gastrointestinal illness was almost twice as high for persons living in an exposed household as compared with persons in unexposed households. In none of the registered episodes did the waterworks personnel consider that there had been a high risk of contaminated water reaching the consumers and no boiling advices were given.

It has been suggested that a substantial proportion of endemic acute gastrointestinal illnesses may be attributed to problems within the distribution system rendering the water unsafe when it reaches the customers' taps. Several investigators have studied the effect of drinking tap water vs drinking bottled water or water treated by in-house water treatment

Table 7 Factors influencing the risk of acute gastrointestinal illness in households exposed to pipe breaks or maintenance work on the water distribution network

Factors	With factor Ill/total	Without factor Ill/total	Risk ratio	95% CI	P-value
Univariate analysis					
Waterwork personnel assessment of risk for contamination (Low risk: 73 episodes, medium risk: 7 episodes)	10/48	59/498	1.8	1.0, 3.2	0.066
Water and sewage pipe in same ditch (71 episodes)	62/482	15/127	1.1	0.6, 1.8	0.752
Use of hyperchlorination (12 episodes[a])	6/104	65/487	0.4	0.2, 1.0	0.042
Swabbing(4 episodes)	8/33	61/549	2.2	1.1, 4.2	0.018
Flushing (77 episodes)	58/514	15/82	0.6	0.4, 1.0	0.067
Rain during work/repair (32 episodes)	23/147	44/396	1.4	0.9, 2.2	0.151
Duration of water shut off >6 h (31 episodes)	33/220	45/383	1.3	0.8, 1.9	0.251
Planned work/repair (38 episodes)	35/276	43/336	1.0	0.7, 1.5	0.966
Multivariable logistic regression model					
Use of hyperchlorination[a]			0.4	0.1, 1.2	0.093
Flushing			0.4	0.2, 0.8	0.008
Duration of water shut off >6 h			1.9	1.0, 3.4	0.044

[a] Only one waterwork.

units on the incidence of gastroenteritis. An intervention trial by Payment *et al.*[6] in Canada suggested that 14–40% of gastrointestinal illness were attributable to tap water meeting current standards and that the distribution system appeared to be partly responsible for this increased risk. Modelling of the distribution system showed that it was very prone to negative pressures.[7] A similar blinded intervention trial in the US[8,9] did not reveal any differences in risk of gastrointestinal illness between households that received the intervention and the control households. However, the study was limited to only one waterwork, which was rated among the best 2% in the country and no negative pressure events occurred during the study period.[1] A similar randomized double-blinded trial was conducted in Melbourne, with similar results of no effect of treatment of tap water.[10]

In a case-control study of sporadic cryptosporidiosis in the UK, risk-factors for diarrhoea in the control group were investigated.[11] The researchers found a strong association between self-reported diarrhoea and low water pressure at the faucet. However, the study was relatively small and due to study design they were unable to confirm that the loss of pressure events preceded the diarrhoea.

An ecological study of environmental risk factors and campylobacteriosis in Sweden showed an increasingly higher risk of infection associated with longer average length of the water distribution system. The authors suggested that this could be caused by intrusion of contaminants in the distribution network,[12] emphasizing the problem with contamination in the water distribution system.

The discrepancies between the results from studies investigating risk of illness caused by contamination in drinking water distribution systems are not surprising, since a variety of factors may influence the results. Differences in study design, especially regarding blinding of the participants, could lead to a placebo effect, thereby giving a higher relative risk in the non-blinded studies. However, differences in the quality of the water supplies and distribution systems in the study areas are also likely to influence the study results, including the technical condition of the pipeline system, amount of leakage, the presence of pathogens in the surroundings of the water pipes and the occurrence of pressure transients in the distribution systems.

During episodes of maintenance work or repair of breaks, there are several possible modes of external contaminants reaching the interior of the water pipes. During normal operation, the water in the distribution network is subject to overpressure. This prevents intrusion of external contaminants through leaks or cracks. In Norway, 20–50% of the water is lost through leakage in the distribution system,[13,14] and therefore it can be anticipated that there is a high potential for water intrusion when the pressure is reduced or even reversed. When the water is closed off in order to conduct work on the distribution system, a negative pressure may occur in parts of the network, especially parts located on a higher level and this may lead to intrusion of water surrounding the pipe.

In a study in the US investigating the presence of microbial contaminants in soil and water samples collected immediately adjacent to drinking water pipelines, faecal coliform bacteria were detected in 43% of the water samples and 50% of the soil samples indicating the presence of faecal contamination.[15] The same study found 56% of the samples positive for viruses; predominantly enteroviruses, but also norovirus and hepatitis A virus were detected, providing clear evidence of human faecal contamination immediately exterior to the pipe. Also in Norway, sewer lines are often located in the same ditch as water pipelines and similar microbiological findings as in the US study may be expected.

To reduce the risk of intrusion, sewer pipes should be located below the water pipes; however, in saturated soil conditions, it has been shown that microbes can move several meters in short periods of time.[16]

An episode causing loss of water pressure in the water pipe may thus lead to intrusion of pathogens present in the surroundings of the pipes, possibly caused by leakage from sewer pipes located nearby. In our study, the clinical symptoms of gastrointestinal illness were generally mild and were similar in the exposed and unexposed households. This can be explained by an intrusion event causing pathogens from leaking sewer pipes entering the water pipes. The kinds of gastrointestinal illnesses caused by contamination during breaks or maintenance work in the water distribution system in the exposed group would therefore reflect the gastrointestinal infections that are endemic in the nearby population.

In the exposed cohort, a higher average water intake in the household increased the risk 4-fold compared with households with a lower water intake, supporting the main results. While the highest rate of gastrointestinal illness was observed in children as expected, the highest relative risk of illness was observed among young adults—the age-group that generally consumes most water.[17] Exposure data were not collected at the individual level and therefore it was not possible to evaluate the effect on individual consumption.

Flushing of the pipelines and use of chlorination after an episode seemed to reduce the risk of illness. General professional guidelines in Norway for water pipeline operations recommend chlorination of water pipelines after maintenance operation, loss of water pressure or both and prior to repressurizing, in order to protect pipeline water from contamination.[18] However, the recommendations are specified to incidents where it is considered to be a risk that contamination has occurred and thus it is often not done. Only one of the seven participating waterworks chlorinated routinely in all episodes of work on the water distribution pipeline. The procedure involved adding calciumhypochlorite [$Ca(OCl)_2$] to the pipe segment when refilling it with water, disinfection for two hours followed by flushing. The amount of calciumhypochlorite in grams was equivalent to the diameter of the pipe in millimetres, in accordance with the guidelines from Norwegian Institute of Public Health. The whole process of chlorination takes a few hours, and the main reason for omitting this step is to minimize the duration of affected households being deprived of pipeline water. However, since the study was not designed to investigate the effectiveness of these measures specifically, the results need to be interpreted with care.

In order to make evidence-based recommendations, further studies are needed to investigate which protective measures the waterworks should implement to reduce the risk of illness most effectively. A 'boil water' notice to the general public on short notice is considered to be ineffective, but may be appropriate to people at special risk, for instance in hospitals or other institutions.

To be able to estimate the disease burden that can be attributed to loss of water pressure associated with mains breaks or maintenance work in the water distribution network, we would need to know the prevalence of exposure. Although there are some figures on registered breaks or scheduled maintenance operations, these are often not complete. In addition, unnoticed pressure transients may occur also during normal distribution system operations, that can lead to intrusion of contaminated water into the water pipe.[1] If we anticipate 20% of the 4.5 million Norwegian inhabitants exposed to one low-pressure episode every year, with an absolute risk difference at the individual level of $7.5\% - 3.9\% = 3.6\%$ (Table 5), this would cause an estimated 33 000 cases of acute gastrointestinal illnesses. However, if we anticipate that pressure transients in the distribution system to be a more common occurrence, causing frequent, smaller intrusion contamination episodes, the estimated disease burden could be large.

Limitations

Some caution is needed in interpreting the results. Our study was based on data from large waterworks supplying mainly urban areas. The results may therefore not be generalizable to smaller waterworks in rural areas, where longer distribution pipelines may be more prone to leaks and pressure transients. As was shown by Kirmeyer *et al.*[1], the distribution system studied by Payment *et al.* [6,19] was very prone to negative pressures. Analysis of the data also showed that the people living far from the treatment plant had the highest risk of gastroenteritis.[1]

Recreational water exposure is another important risk factor for waterborne disease. During summer, use of private small plastic pools filled with tap water can pose another risk for exposure of contaminated water after low-pressure episodes. This exposure was not assessed in the present study, but may explain some of the higher risk in the exposed households.

For some pathogens, such as Giardia and Cryptosporidium, the incubation period may be longer than one week. Since we used only 1-week follow-up period, we would not include the effect of contamination with pathogens with longer incubation period. This may have reduced our calculated risk estimates to some degree. However, the endemic level of these pathogens in Norway is considered to be low.

Although we tried to accomplish blinding of the participants regarding the exposure, this was not completely successful. This may have led to some recall bias among the participants and therefore may have influenced our results. However, when stratifying on whether the households believed they had been exposed, the adjusted RR was only slightly lower than the unadjusted, thereby indicating that this did not have a large influence on the results.

In our study, we included several medium to large-sized waterworks, from different parts of Norway. This gives a more representative picture of the risk, and makes the results more generalizable than studies involving only single waterworks. Even if the study was too small to provide a precise risk estimate for each waterwork separately, the estimates pointed in the same direction. The increased risk associated with higher average daily water intake also supports our conclusions that the association is causative.

Conclusion

To our knowledge, this is the first study to assess the risk of gastrointestinal illness following breaks or maintenance work on the water distribution system and our results indicate an increased risk of acute gastrointestinal illness in affected households. The risk was highest in households with higher average water consumption. The clinical symptoms were generally mild and of short duration. Intrusion of polluted water related to loss of water pipeline pressure has been suggested as a potential risk to public health, but has to our knowledge not been directly addressed in analytical epidemiological studies. Results and conclusions from our study support the hypothesis of such an association.

This study needs to be followed up to establish effective preventive measures in order to prevent illnesses associated with contamination in the distribution network. Better data on the occurrence of low-pressure episodes and improved registration of mains breaks and maintenance work on the water distribution network in urban and rural areas are needed in order to better assess the public health burden of contamination in the water distribution network.

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KEY MESSAGES

- Breaks and maintenance work in the water distribution systems increased the risk of gastrointestinal illness among exposed households in a cohort study in Norway.
- The risk of drinking water contamination during repair of pipeline breaks was considered small or negligible by the water work personnel.
- The public health burden caused by contamination of drinking water within the distribution network may be larger than anticipated, and need further assessment.

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BRIEF REPORT

Self-Reported Diarrhea in a Control Group: A Strong Association with Reporting of Low-Pressure Events in Tap Water

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In a recently conducted case-control study of sporadic cryptosporidiosis, 6.6% of subjects in the control group reported having had diarrhea in the 2 weeks before completion of the questionnaire. In an analysis of this control group, there was a very strong association between self-reported diarrhea and reported low water pressure at the faucet.

Acute diarrhea is a common symptom in the developed world, especially among the youngest members of our society. Actual estimates of illness vary depending on the method used to ascertain illness rates, on the case definitions, and on the country [1]. In the United States, with use of a retrospective study design, it was estimated that there are 140 episodes of diarrhea for every 100 person-years [2]. In the United Kingdom, retrospective studies estimate illness rates to be 55–95 episodes for every 100 person-years [3–5]. Prospective studies seem to give a substantially lower estimate. In the United Kingdom, a prospective study reported an attack rate of 19.4 episodes per 100 person-years [5], and in a Canadian study, the rate was 76 episodes per 100 person-years among people who did not use water filters [6]. Although only a small proportion of these patients present to the health service, the economic cost of diarrheal disease in the United Kingdom is large: ~£743 million per annum at 1995–1996 prices [7]. In the large majority of cases, it is unclear where people have acquired infection. We recently conducted a large case-control study of the risk factors for sporadic cryptosporidiosis and found that a significant proportion of the control group reported diarrhea in the 2 weeks before receipt of the questionnaire [8]. We took the opportunity to study associations between risk factors and the presence of diarrhea in the control group for this study to determine any indications of possible risk factors for diarrhea in the United Kingdom.

The postal questionnaire–based case-control study was conducted in Wales and the northwest region of England from February 2001 to May 2002. Full details of the study are provided elsewhere [8]. The combined population of the 2 regions covered by this study region is >9 million people and covers both heavily industrialized and rural areas. There are 3 main water utilities supplying these regions, which between them have ~240 water treatment works. Sources of drinking water and treatments vary, but overall, the microbiological quality of the water is excellent, with <0.05% of water samples testing positive for *Escherichia coli* (http://www.dwi.gov.uk/consumer/qualityinfo6.shtm).

For the purposes of this report, 427 control subjects returned their questionnaires, a 52% response rate. Of these 427 responses, 28 respondents (6.6%) reported having had diarrhea in the 2 weeks before receipt of the questionnaire, and 4 did not answer the question. These 4 persons were excluded from this analysis. Thus, the incidence of diarrhea in our control group was 86 cases per 100 person-years, which is in line with previous retrospective studies in the United Kingdom [3–5]. Statistical analysis in this study was identical to that used for the larger case-control study: the χ^2 test or Fisher's exact test were used for univariable analysis, and logistic regression analysis was used for multivariable analysis [8]. All analyses were done using SPSS software, version 12.0 (SPSS). All variables that were significant at the $P<.01$ level were included in a logistic regression model. The least significant variable was then removed from the model, which was then recalculated. This continued until all variables were significant at the $P<.1$ level. The final model is shown in table 1.

Four variables remain significant in the final model. There was a positive association with feeding young children and a negative association with consumption of yogurt at the $P<.05$ level. We are unable to explain this latter observation, although it is interesting to speculate whether this could have been the result of a probiotic effect of the bacteria in yogurt [9]. The strong association with contact with someone else who had diarrhea is also not surprising, given the known likelihood of person-to-person transmission of many enteric pathogens. The most surprising finding was the very strong association

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Table 1. Multivariable model of risk factors for diarrhea in a control group.

Variable	Adjusted OR (95% CI)	P
Feeding a child aged <5 years old		
Yes	2.520 (1.045–6.079)	.040
No	1.000	
Contact with another person ill with diarrhea		
Yes	6.959 (2.296–21.092)	.001
No	1.000	
Loss of water pressure at home		
Yes	12.496 (3.493–44.707)	<.001
No	1.000	
Frequency of yogurt consumption		
Not at all	1.000	.016
1–2 times per week	0.947 (0.319–2.815)	
3–7 times per week	0.283 (0.083–0.970)	
Most days	0.186 (0.054–0.641)	

NOTE. Findings are estimated from 384 observations (for 27 case patients and 357 control subjects).

(OR, 12.5; 95% CI, 3.5–44.7; $P<.001$) with reporting of loss of water pressure at the home tap.

Most of the reported episodes of pressure loss were associated with reported disruption of the water supply and are likely to be related to burst water mains. Thus, many of the excess cases of illness identified in this study could be associated with contamination of water during a burst. Even in the absence of an actual burst, low water pressure in distribution systems is a well-known risk factor for outbreaks of waterborne disease, especially in low-income countries [10]. However, there have been few outbreaks reported from developed nations and no epidemiological evidence of an association with sporadic infections or disease. The suggestion that contamination of water in distribution may lead to increased risk of diarrhea—even in developed nations—has been made before, although not in association with low–water pressure events specifically [11]. Recently, workers in the United States have shown that low–water pressure events in otherwise satisfactory water distribution pipes can aspirate enteric organisms that contaminate the soil surrounding the pipe [12].

The question remains whether the observed association could be an artifact; the study was not designed to test the hypothesis that low–water pressure events were associated with self-reported diarrhea, the questions were not specifically designed to look for events occurring before the onset of diarrhea, and there remains the possibility of recall bias. The study design asked persons to self-report diarrhea and water pressure loss in the 2 weeks before receipt of the questionnaire, so we are unable to confirm that the loss of pressure events preceded the diarrhea, although it is difficult to understand how an association could occur in which diarrhea preceded the loss of water pressure other than by chance. Given that this was a postal questionnaire–based study, we were unable to analyze stool specimens and are not able to confirm the nature and cause of the diarrheal illness. With regard to recall bias, loss of was pressure was just one of many possible risk factors that were investigated in the questionnaire. Although *Cryptosporidium* species have caused several waterborne outbreaks of diarrhea in the northwest region, loss of water pressure was not associated with cryptosporidiosis in the larger study, and many other water-related variables, such as discoloration, were not associated with diarrhea. The very strong association found in this analysis suggests that our results are unlikely to be an artifact.

If our finding is repeatable, then a substantial proportion of cases of gastrointestinal illness in the United Kingdom and probably in the United States (up to ~15%) may be associated with the consumption of drinking water that has been contaminated as a result of a burst water main or other loss of pressure in the distribution system. The costs of illness related to such low–water pressure events could exceed £100 million per annum in England and Wales (15% of the total annual cost of diarrheal disease discussed above). Such an observation has significant policy implications and will affect the cost-benefit analyses for improving the state of the aging water supply distribution system in many industrialized nations. Such a finding would also lead to significant changes in how low–water pressure events in public water supplies are managed.

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